PERIODICAL
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兵庫農科大学研究報告

第5巻 第1号

自然科学編

THE SCIENCE REPORTS
OF THE
HYOGO UNIVERSITY OF AGRICULTURE

Vol. 5 No. 1

Series: Natural Science

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兵庫農科大学

昭和36年

Sasayama, Hyogo, Japan

1961

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THE CATALOGUE OF THE JAPANESE TIPULIDAE, WITH THE KEYS TO THE GENERA AND SUBGENERA (Diptera)

VII. LIMONIINAE, TRIBE ERIOPTERINI (2)

Hiroshi ISHIDA

Genus **ORMOSIA** ROND., 1856

Ormosia ROND.: PDI, 1:180; SCHIN.: FA, 537 (1864); O. S.: MD, 4:12, 139 (1869); BEZ, 31:231 (1887); COQ.: PUNM, 37:581 (1910); ALEX.: MCAS, 25:902, 911-3 (1919); PUNM, 58:416, 422 (1920) (with MCATEE); MCAS, 38:909, 910, 922-3 (1920) [L; P]; FG, 51 (1934); BCSS, 64:425, 462-5 (1942); PIERRE: FF, 8:91, 94-5, 142, f. g (L), g^1 (P) (1924); END.: TM, 19 (1936); WU: CIS, 5:58-9 (1939); LACKS.: ANMW, 50:26-7 [*Rhypholophus*] (1940); COE: HIBI, 46-7, 58-61 (1950) [k].

Type: *Erioptera nodulosa* MACQ.

Rhypholophus KOL., 1860: *WEM, 4:393; SCHIN.: FA, 2:xxvii, 536 (1864); O. S.: MD, 4:47, 139-41, 149 (1869); BEZ, 31:192 (1887); SKUSE: (2)4:800 (1890); KERT.: KPD, 1:289-91 (1903); BRUN.: FBI, 438, 440-1, XI:20 (a) (1912); RIM, 17:235-6 (1920); ALEX.: PUNM, 44:492 (1913); LACKS.: ANMW, 50:25-7 (1940) [k]; COE: HIBI, 47, 61 [*Ormosia*] (1950).

Type: *Rhypholophus phryganopterus* KOL.

Dasyptera SCHIN., 1863: WEM, 7:221; FA, 2: xxvii, 537-8 (1864); O. S.: MD, 4:139-40, 149 (1869); COQ.: PUNM, 37:531 (1910).

Type: *Erioptera varia* WIED.

Subgenus **OREOPHILA** LACKS., 1935

Oreophila LACKS.: *Troms. Mus. Arsh., 53(4):7; ANMW, 50:34-5 (1940); ALEX.: PJS, 86:318 [*Ormosia*] (1958).

Type: *Rhypholophus bergrothi* STROBL

Ilisomya ROND., 1856: PDI, 1:180; O. S.: BEZ, 31: 231 (*Ilisomyia*!) (1887).

Type: *Ilisomya nebulosa* ROND. (as *nubipennis*, sp. nov. [nom. nud.]).

O. (O.) confluenta ALEX., 1922: IIM, 10:182-3 (No Sg), t: Mt. Minomo (♀); PJS, 67:163 (Sg *Ormosia*) (1938); PJS, 71:60 (Sg *Ormosia*) (1940) [n]; AESA, 43:435 (Sg *Ormosia*) (1950); PJS, 82:71 (Sg *Ormosia*) (1953); PJS, 86:318 (1958).

Dist: JAPAN (Honshu; Shikoku).

Subgenus **Incertae sedis**

O. tokionis ALEX., 1919: AESA, 12:336, t: Meguro, Tokio (♂♀); PJS, 82:304 (1954); PJS, 86:318 (1958); ESAKI: IIJ, 208, f. 405 (♂) (1932); IIJ, ed. 2, 1527, f. 4380 (♂) (1950).

Dist: JAPAN (Honshu; Shikoku).

Nom. Jap.: *Hosoba-kuro-hime-gagambo* (ESAKI).

Subgenus **SCLEROPROCTA** EDW., 1938

Scleroprocta EDW.: *TSBE, 5:137 [*Ormosia*]; COE: HIBI, 46, 60 [*Ormosia*] (1950).

Type: *Erioptera facipennis* ZETT.

O. (S.) cinctifer ALEX., 1919: AESA, 12:336-7 (No Sg), t: Meguro, Tokio (♂♀); PJS, 82:303 (1954).

Dist: JAPAN (Honshu; Shikoku).

Subgenus **ORMOSIA,** s. str.

O. (O.) aculeata ALEX., 1924: AESA, 17:65-6, (No Sg), t: Mt. Takao, Musashi, alt. 1,000-2,000 ft. (♂♀); PJS, 50:156 (No Sg) (1933) [n].

Dist: JAPAN (Honshu).

O. (O.) amakazarii ALEX., 1958: PJS, 86:318-9, VII:54 (w), 56 (h), t: Mt. Amakazari, Echigo, alt. 1,000 m. (♂).

Dist: JAPAN (Honshu).

O. (O.) atripes ALEX., 1919: AESA, 12:335 (No Sg), t: Meguro, Tokio (♀); PJS, 60:193 (No Sg) (1936) [as synonym of *diversipes*]; PJS, 82:173 (1953).

Dist: JAPAN (Honshu; Shikoku).

O. (O.) deprava ALEX., 1941: PJS, 76:62-3, I:23 (w), t: Kamikochi, alt. 5,000 ft. (♀).

Dist: JAPAN (Honshu).

O. (O.) dicax ALEX., 1947: AESA, 40:369-70, t: Hamasaka, Hyogo (♂♀).

Dist: JAPAN (Honshu).

O. (O.) diversipes ALEX., 1919: AESA, 12:334-5 (No Sg), t: Meguro, Tokio (♂); PJS, 42:508 (No Sg) (1930); PJS, 60:193 (1936) [n].

Dist: JAPAN (Honshu; Kyushu).

O. (O.) echigoensis ALEX., 1957: PJS, 85:381-2, IV:36 (w), 40 (h), t: Kurokawa, Echigo (♂).

Dist: JAPAN (Honshu).

O. (O.) horiana ALEX., 1925: AM, (9)15:69-70 (No Sg), t: Mt. Wakasugi, Chikuzen, alt. 2,500 ft. (♂♀); PJS, 50:156 (No Sg) (1933) [n].

Dist: JAPAN (Kyushu).

O. (O.) kamikochiae ALEX., 1947: AESA, 40:368-9, t: Kamikochi, Shinano, alt. 5,000 ft. (♂♀).

Dist: JAPAN (Honshu).

O. (O.) laevistyla Alex., 1933: PJS, 50:155–6, I: 21 (w), III:47 (h) (No Sg), t: Kibune, Kyoto, alt. 750 ft. (♂); PJS, 82:303–4 (1954) [n].

Dist: JAPAN (Honshu; Shikoku).

O. (O.) machidana Alex., 1933: PJS, 51:401–2, I: 21 (w), IV:51 (h) (No Sg), t: Mt. Shirouma, Shinano (♂); AESA, 40:369 (*machidai*!) (1947).

Dist: JAPAN (Honshu).

O. (O.) nantaisana Alex., 1921: AESA, 14:117 (No Sg), t: Nantaisan (♂); AESA, 40.368 (1947); TSES, 3:83 (1953); PJS, 82:304 (No Sg) (1954); PJS, 86:320, VII:57 (h) (1958).

Dist: JAPAN (Honshu; Shikoku).

O. (O.) nippoalpina Alex., 1941: PJS, 76:63–4, I:24 (w), IV:45 (h), t: Kamikochi, alt. 5,000 ft. (♂♀).

Dist: JAPAN (Honshu).

O. (O.) ontakeana Alex., 1947: AESA, 40:367–8, t: Ontake, Hida, southern Alps, alt. 5,850 ft. (♀).

Dist: JAPAN (Honshu).

O. (O.) rectangularis Alex., 1934: PJS, 53:293–4, I:20 (w), III:40 (h) (No Sg), t: Yumoto, Shimotsuke, alt. 4,850 ft. (♂♀).

Dist: JAPAN (Honshu).

O. (O.) remissa Alex., 1953: PJS, 82:71–2, II:22 (w), 29 (h), t: Mt. Tsurugi, Awa, alt. 1,400 to 1,955 m. (♂).

Dist: JAPAN (Shikoku).

O. (O.) seclusa Alex., 1935: PJS, 58:422–3, I:24 (w), IV:50 (h) (No Sg), t: Konseitoge, Shimotsuke, alt. 7,000 ft. (♂♀); AESA, 40:369 (1947).

Dist: JAPAN (Honshu).

O. (O.) subalpina Alex., 1947: AESA, 40:366–7, t: Mt. Kurobegoro, Toyama (Japanese Alps), alt. 2,400 m. (♂♀); PJS, 86:320–1, VII:58 (h) (1958).

Dist: JAPAN (Honshu).

O. (O.) takahashii Alex., 1919: AESA, 12:337–8 (No Sg), t: Meguro, Tokio (♂♀); AESA, 40: 370 (1947).

Dist: JAPAN (Honshu).

O. (O.) takeuchii Alex., 1921: AESA, 14:117–8 (No Sg), t: Gifu (♂♀); PJS, 42:508 (No Sg) (1930); PJS, 53:267 (No Sg) (1934); AESA, 40: 370 (1947); TSES, 3:83 (1953); Esaki: IIJ, 207, f. 404 (♂) (No Sg) (1932); IIJ, ed. 2, 1526, f. 4379 (♂) (No Sg) (1950); Shir.: CI, 644 (No Sg) (1954).

Dist: JAPAN (Hokkaido; Honshu; Shikoku; Kyushu).

Nom. Jap.: *Hanebiro-hime-gagambo* (Esaki).

O. (O.) tokunagai Alex., 1932: PJS, 49:129–30, I:19 (w), III:45 (h) (No Sg), t: Kibune, Kyoto, alt. 750 ft. (♂).

Dist: JAPAN (Honshu).

Genus **ERIOPTERA** Meig., 1803

Erioptera Meig.: *Illiger's Mag., 2:262; *SB, 1: 108 [xxii, 85–6] (1818); Macq.: HNI, 1:72, 109–10 (1834); Zett.: DS, 10·3771–4 (1851); Big.: ASEF, (3)2:472 (1854); O. S.: MD, 4:47, 146–55 (1869); BEZ, 31:193–5 (1887); Skuse: PLSN, (2)4:818–9 (1890); Kert.: KPD, 1:294–6 (1903); Coq.: PUNM, 37:540 (1910); Brun.: FBI, 438, 445–9 (1912); RIM, 15:309 (1918); RIM, 17:327–8 (1920); Alex.: PUNM, 44:492, 512–3 (1913); MCAS, 25:902, 908–9 (1919) [k]; PUNM, 58:416, 417–8 (1920) [k] (with McAtee); MCAS, 38:909, 910, 914–5 (1920) [L; P]; PJS, 48:624–5 (1932) [k]; FG, 50, 52 (1934) [k]; BCSS, 64:425, 426, 445, 448–9 (1942) [k]; MPMM, 90:11–2 (1955); Pierre: FF, 8:92, 101–2, 142, f. h (L), h^1 (P) (1924); End.: TM, 20, f. 28 (w) (1936); Wu: CIS, 5:50–2 (1939); Lacks.: ANMW, 50:39–40 (1940); Coe: HIBI, 47, 54–8, f. 18e (lower parts of pleurae, with mid & hind coxae), 21b (wing-base) (1950) [k].

Type: *Erioptera lutea* Meig.

Polymeda Meig., 1800: *Nouv. Class. Mouch., 14 [nom. nud.]; Coq.: PUNM, 37:593–4 (1910); Stone: AESA, 34:413–4 (1941).

Type: *Erioptera lutea* Meig.

Polyraphia Merg., 1818: in Meig., *SB, 1:111 [88]; Coq.: PUNM, 37:594 (1910).

Type: *Erioptera taenionota* Wied. (as *pallidipennis* Merg.).

Octavia Big., 1854: ASEF, (3)2:474; Coq.: PUNM, 37:577 (1910).

Type: *Erioptera taenionota* Wied.

Chemalida Rond., 1856: PDI, 1:180; O. S.: BEZ, 31:231 (1887); Coq.: PUNM, 37:522 (1910).

Type: *Erioptera taenionota* Wied.

Limnoea Rond., 1856: PDI, 1:181; O. S.: BEZ, 31: 231 (*Limnaea*!) (1887); Coq.: PUNM, 37:561 (1910) [praeocc. by Poli, 1791].

Type: *Tipula flavescens* Linné

Limnoica Rond., 1861: PDI, 4:11 [nom. nov. for *Limnoea*]; O. S.: BEZ, 31:231 (1887); Coq.: PUNM, 37:561 (1910).

Type: *Tipula flavescens* Linné

Subgenus **CHEILOTRICHIA** Rossi, 1848

Cheilotrichia Rossi: *Verz. österreich. Dipt., 12; O. S.: BEZ, 31:194–5 [*Erioptera*] (1887); Kert.: 1:296 (1903); Pierre: FF, 8:92, 104 (1924); Alex.: PJS, 24:587 (1924); PJS, 59:254 [*Erioptera*] (1936); End.: TM, 20 (1936); Coe: HIBI, 47, 53–4 (1950) [k].

Type: *Erioptera imbuta* Wied.

E. (C.) laetipennis Alex., 1936: PJS, 59:252–3, I:23 (w), II:36 (h), t: Kibune, Kyoto (♂♀).

Dist: JAPAN (Honshu).

Subgenus **EMPEDA** O. S., 1869

Empeda O. S.: MD, 4:47, 183–4; BEZ, 31:203 (1887); KERT.: KPD, 1:301 (1903); COQ.: PUNM, 37:537 (1910); BRUN.: FBI, 439, 475 (1912); RIM, 17:239–40 (1920); BERGR.: Psyche, 22:56 (1915); ALEX.: MCAS, 25:901, 908, 909 [*Erioptera*] (1919); PUNM, 58:416, 418 [*Erioptera*] (1920) (with MCATEE); PJS, 48:624 [*Erioptera*] (1932); FG, 50 [*Erioptera*] (1934); PJS, 59:254 [*Erioptera*] (1936); ECSS, 64:445, 446 [*Erioptera*] (1942); PIERRE: FF, 8:92, 109–10 (1924); END.: TM, 21 (1936); WU: CIS, 5:50 [*Erioptera*] (1939).

Type: *Empeda stigmatica* O. S.

Ilisophila ROND., 1856: PDI, 1:180; O. S.: BEZ, 31:231 (1887).

Type: *Erioptera lutea* ROND. [nec MEIG.].

Platytoma LIOY, 1863: *Atti Ist. Veneto (3)9:226; EDW.: Ent. mo. Mag., 75:248 [*Cheilotrichia*] (1939); COE: HIBI, 47, 54 [*Cheilotrichia*] (1950).

Type: *Erioptera cinerascens* MEIG.

E. (E.) brumalis ALEX., 1947: AESA, 40:365–6, t: Gifu (♂♀); PJS, 82:302 (1954).

Dist: JAPAN (Honshu; Shikoku).

E. (E.) japonica ALEX., 1920: IIM, 8:134–5, t: Tokyo (♀); AZ, 27A(17):23 (1936) [n]; PJS, 83:301, IV:37 (w) (1954).

Dist: JAPAN (Honshu; Shikoku).

E. (E.) microtrichiata ALEX., 1930: PJS, 42:80, II:35 (h), t: Mt. Kirishima, alt. 2,500 ft.; Kosugidani, Yakushima, alt. 2,500 ft. (♂♀).

Dist: JAPAN (Kyushu).

E. (E.) nigroapicalis ALEX., 1920: AESA, 13: 255–6, t: Funkiko, Formosa (♂♀); TSES, 3:82 (1953); PJS, 82:303, V:46 (w) (1954).

Dist: JAPAN (Shikoku); FORMOSA.

Subgenus **ARCTOCONOPA** ALEX., 1955

Arctoconopa ALEX.: MPMM, 90:17 [*Erioptera*].

Type: *Psiloconopa forcipata* LUNDST.

E. (A.) bifurcata ALEX., 1919: AESA, 12:338–9 (No Sg), t: Meguro, Tokio (♂); PJS, 49:399 (Sg *Ilisia*) (1932) [n]; PJS, 57:223 (Sg *Psiloconopa*) (1935); MPMM, 90:17 (1955).

Dist: JAPAN (Honshu).

Subgenus **PSILOCONOPA** ZETT., 1838

Psiloconopa ZETT.: *Ins. Lapp., Dipt., 847; DS, 10: 4007 (1851); SCHIN.: FA, 2:573 (1864); O. S.: MD, 4:47, 173–4, 176 (1869); MD, add., IX (1873); BEZ, 31:196–7 (1887); KERT.: KPD, 1:298 (1903); PIERRE: FF, 8:92, 111 (1924); ALEX.: FG, 52 [*Erioptera*] (1934); BCSS, 64:445, 458 [*Erioptera*] (1942); AESA, 40:365 [*Erioptera*] (1947); MPMM, 90:22 [*Erioptera*] (1955); END.: TM, 21 (1936); WU: CIS, 5:52 [*Erioptera*] (1939); COE: HIBI, 47, 57 [*Erioptera*] (1950).

Type: *Psiloconopa meigeni* ZETT.

Simplecta! ROND., 1856: PDI, 1:181 [nec MEIG., 1830].

Type: *Limnobia stictica* MEIG. (as *stictiga*!).

Ilisia ROND., 1856: PDI, 1:182; *Mus. Canestr., 3: 91 (1865); SCHIN.: FA, 2:538 (1864); O. S.: BEZ, 31:232 (1887); PIERRE: FF, 8:92, 104–5 (1924); ALEX.: PJS, 48:624–5 [*Erioptera*] (1932); FG, 52 [*Erioptera*] (1934); ECSS, 64:445, 459–60 [*Erioptera*] (1942); MPMM, 90:11 [*Erioptera*] (1955); END.: TM, 20, f. 29 (w) (1936); WU: CIS, 5:51–2 [*Erioptera*] (1939); COE: HIBI, 47, 57–8 [*Erioptera*] (1950).

Type: *Erioptera maculata* MEIG.

Trichosticha SCHIN., 1863: WEM, 7:221; FA, 2: XXVII, 538–41 (1864); O. S.: MD, 4:149 (1869); BRUN.: RIM, 17:239 (1920).

Type: *Erioptera maculata* MEIG.

Acyphona O. S., 1869: MD, 4:151–2, 158 [*Erioptera*]; BEZ, 31:193 [*Erioptera*] (1887); KERT.: KPD, 1:293 (1903); ALEX.: CE, 45:287–8 [*Erioptera*] (1913) [key to spp.]; MCAS, 25:908, 909 [*Erioptera*] (1919); PUNM, 58:418 [*Erioptera*] (1920) (with MCATEE); BERGR.: Psyche, 22:57 (1915); BRUN.: RIM, 17:238–9 (1920).

Type: *Erioptera venusta* O. S.

Symplectomorpha MIK, 1886: WEZ, 5:318; COQ.: PUNM, 37:610 (1910); BRUN.: RIM, 17:249 (*Symplectromorpha*!) (1920); PIERRE: FF, 8:92, 106 (1924); END.: TM, 20, f. 31 (w) (*Symplectromorpha*!) (1936).

Type: *Limnobia stictica* MEIG.

Kowarzia THALHAMMER, 1899: *Fauna Reg. Hung., Dipt., 19.

Type: *Symplecta grata* LOEW

E. (P.) amamiensis ALEX., 1955: AM, (12)8:672–3, t: Yuwan, Amami O Shima (♂♀).

Dist: JAPAN (Loochoo Is.: Amami-Oshima I.).

E. (P.) asymmetrica ALEX., 1913: CE, 45:288, 289–90, III:15 (w), X:7–9 (h) (Sg *Acyphona*), t: Tokio (♂♀); PJS, 24:584 (Sg *Acyphona*) (1924); PJS, 31:380 (Sg *Ilisia*) (1926); PJS, 42:508 (Sg *Ilisia*) (1930); PJS, 71:65 (Sg *Ilisia*) (1940); PJS, 82:72 (1953); ESAKI: IIJ, 209, f. 407 (♀) (No Sg) (1932); IIJ, ed. 2, 1527, f. 4382 (♀) (No Sg) (1950).

Dist: JAPAN (Hokkaido; Honshu; Shikoku; Kyushu); N. KOREA.

Nom. Jap.: *Ko-madara-hime-gagambo* (ESAKI).

E. (P.) incongruens ALEX., 1913: CE, 45:288–9, X:5–6 (h) (Sg *Acyphona*), t: Tokio (♂); TAES, 46:9 (Sg *Acyphona*) (1920) (♀, Allotype: Meguro, Tokio); PJS 55:57 (Sg *Ilisia*) (1934) [n].

Dist: JAPAN (Honshu).

E. (P.) laudatrix Alex., 1947: AESA, 40:364-5, t: Gifu (♂).
Dist: JAPAN (Honshu).

E. (P.) machidai Alex., 1931: PJS, 44:363-4, I: 19 (w) (Sg *Ilisia*), t: Hirayu, Japanese Alps, Shinano (♀); AESA, 40:365 (1947); PJS, 86:324, VII:55 (h) (1958).
Dist: JAPAN (Honshu).

E. (P.) nigrohalterata Alex., 1958: TSES, 6:8, t: Matsuyama, Iyo (♂♀).
Dist: JAPAN (Shikoku).

E. (P.) verna (Alex., 1920): IIM, 8:135 [*Psiloconopa*], t: Tamagawa, Tokyo (♂).
Dist: JAPAN (Honshu).

E. (P.) yezoana Alex., 1924: PJS, 24:585-6, II: 16, 18, 20 (h) (Sg *Acyphona*), t: Shitakara (♂).
Dist: JAPAN (Hokkaido).

Subgenus **SYMPLECTA** Meig., 1830

Symplecta Meig.: SB, 6:282-3; Macq.: HNI, 1:72, 108-9 (1834); Westw.: *Intr., 2, Synops., 128 (1840); Zett.: DS, 10:3907-8 (1851); Big.: ASEF, (3)2:472 (1854); Schin.: FA, 2:xxvii, 545-6 (1864); O. S.: MD, 4:47, 170-1 (1869); MD, add., ix (1873); BEZ, 31:197 (1887); Mik: WEZ, 5: 317-8 (1886); Kert.: KPD, 1:298-9 (1903); Coq.: PUNM, 37:610 (1910); Brun.: FBI, 439, 485-6 (1912); RIM, 17:249 (1920); Wu: CIS, 5:52 [*Erioptera*] (1939); Alex.: PJS, 71:67 [*Erioptera*] (1940); BCSS, 64:425, 443-4 (1942); MPMM, 90:22 [*Erioptera*] (1955); Coe: HIBI, 47, 56-7 [*Erioptera*] (1950).
Type: *Limonia hybrida* Meig.

Helobia St. Fargeau et Serville, 1823: Encycl. Meth., Ins., 10: 585; Alex.: PUNM, 44:492, 511-2] (1913); MCAS, 25:902, 907 (1919); PUNM, 58:] 416 (1920) (with McAtee); MCAS, 38:909, 910,] 928-9 (1920) [L; P]; FG, 51 (1934); PJS, 71:67] (foot-note 4) (1940); Pierre: FF, 8: 92, 106, 142,] f. i[1] (L) (1924); End.: TM, 20, f. 30 (w) (1936)] [praeocc. by Stephens, 1827].
Type: *Limonia hybrida* Meig. (as *Limnobia punctipennis* Meig.).

Idioneura Phil., 1865: VZBG, 15:615; Coq.: PUNM, 37:555 (1910) [praeocc. by Selys, 1860].
Type: *Idioneura macroptera* Phil.

E. (S.) hybrida (Meig., 1804): *Klass., 1:57, III: 17 [*Limonia*]; Alex.: PJS, 24:587 [*Helobia*] (1924); PUNM, 68(4):12 [*Helobia*] (1925); PJS, 71:67 (1940); MPMM, 90:28, f. 34 (h) (1955); Esaki: IIJ, 207, f. 403 (♀) [*Helobia*] (1932); IIJ, ed. 2, 1523, f. 4378 (♀) [*Helobia*] (1950); Edw.: *TSEE, 5:126, f. 24A, g (h) (1938); Wu: CIS, 5:52 (1939); Coe: HIBI, 56 (1950).

punctipennis (Meig., 1818): *SB, 1:147 [117], V:2 (head), 3 (mouth parts), 7 (w) [*Limnobia*], t: Europa; SB, 6:283 [*Symplecta*] (1830); Macq.: HNI, 1:109, II:11 (♀), 12 (head) [*Symplecta*] (1834); Zett.: DS, 10:3908-9 [*Symplecta*] (1851); Schin.: FA, 2:545-6 [*Symplecta*] (1864); Kert.: KPD, 1:298 [*Symplecta*] (1903); Brun.: FBI, 486-7, IX:15 (w) [*Symplecta*] (1912); RIM, 17: 249 [*Symplecta*] (1920); Pierre: FF, 8:106, f. 399 (w), 401 (h) [*Helobia*] (1924); End.: TM, 20, f. 30 (w) [*Helobia*] (1936).
Dist: JAPAN (Hokkaido); SAKHALIN; N. KOREA; CHINA; N. PALAEARCTIC REGION; HIMALAYAS; W. ALASKA.
Nom. Jap.: *Hoshi-usuba-gagambo* (Esaki).

Subgenus **HOPLOLABIS** O. S., 1869

Hoplolabis O. S.: MD, 4:152, 160 [*Erioptera*]; Alex.: MCAS, 25:908, 909 [*Erioptera*] (1919); PUNM, 58:418 [*Erioptera*] (1920) (with McAtee); MCAS, 38:921 [*Erioptera*] (1920); FG, 52 [*Erioptera*] (1934); ECSS, 64:455, 459 [*Erioptera*] (1942); Wu: CIS, 5:41 [*Erioptera*] (1939).
Type: *Erioptera armata* O. S.

E. (H.) asiatica Alex., 1918: AESA, 11:447-8, t: Kioto (♀); EM, 3:124-5 (1919); PJS, 24:586 (1924); PJS, 82:303 (Sg *Psiloconopa*) (1954); Mushi, 27:30-1 (1954); MPMM, 90:30, f. 25 (w), 29 (h) (1955); Esaki: IIJ, 208, f. 406 (♀) (No Sg) (1932); IIJ, ed. 2, 1527, f. 4381 (♀) (No Sg) (1950); Wu: CIS, 5:51 (1939); Shir.: CI, 644, f. 1202 (♀) (No Sg) (1954).
Dist: JAPAN (Hokkaido; Honshu); SAKHALIN; E. SIBERIA; KOREA; N. CHINA; ALASKA.
Nom. Jap.: *Hoshi-hime-gagambo* (Esaki).

Subgenus **ERIOPTERA,** s. str.

E. (E.) alboguttata Edw., 1916: AM, (8)18:252, XII:4 (h), t: Arisan, Formosa (♂); Brun.: RIM, 17:238 (1920); Alex.: RIM, 29:210, 211 (1927) [n]; PJS, 50:160 (1933) [n].
Dist: FORMOSA.

ssp. **daisenica** Alex., 1936: PJS, 59:252, II:35 (h) (*alboguttata*, ssp.), t: Mt. Daisen, Hoki (♂).
Dist: JAPAN (Honshu).

E. (E.) bicornifer Alex., 1921: AESA, 14:116, t: Nakano (♂); PJS, 71:63 (1940).
Dist: JAPAN (Honshu); N. KOREA.

E. (E.) dama Alex., 1958: PJS, 86:324-5, VIII:59 (w), 63 (h), t: Kurokawa, Echigo (♂).
Dist: JAPAN (Honshu).

E. (E.) elegantula Alex., 1913: CE, 45:290-1, III:3 (w), t: Tokio (♂♀); FUNM, 58:435, XXVI:6 (w) (No Sg) (1920) (with McAtee); PJS, 24:582 (1924); PJS, 31:368 (1926) [n]; PJS, 82:72-3 (1953).
Dist: JAPAN (Hokkaido; Honshu; Shikoku).

E. (E.) harukawai Alex., 1926: PJS, 31:368, I:4 (w), t: Kurashiki, Okayama, alt. 12 m.; Gifu, Mino (♂).
Dist: JAPAN (Honshu).

E. (E.) holoxantha Alex., 1936: PJS, 60:190–1, I:15 (w), III:34 (h), t: Iwate-gun, Iwate, alt. 3,000 ft. (♂).
Dist: JAPAN (Honshu).

E. (E.) horii Alex., 1924: PJS, 24:583–4, II:22 (h), t: Jozankei, Hokkaido; Toyohara, Saghalien; Sapporo, Hokkaido; Kamiotoineppu, Hokkaido; Abashiri, Hokkaido (♂♀); PJS, 71:64 (1940); TSES, 3:83 (1953).
Dist: JAPAN (Hokkaido; Honshu; Shikoku); SAKHALIN; N. KOREA.

E. (E.) juvenilis Alex., 1933: PJS, 50:157–8, I:23 (w), t: Shirouma-dake, Japanese Alps (♀); PJS, 66:337, III:43 (h) (1938) (♂, Allotype: Mt. Omei, White Cloud Temple, Szechwan, China, alt. 9,000 ft.); Wu: CIS, 5:51 (1939).
Dist: JAPAN (Honshu); CHINA.

E. (E.) orbitalis Alex., 1924: PJS, 24:584, t: Sapporo (♀); RIM, 50:356 (1953).
ornatifrons Edw., 1927: Spol. Zeyl., 14:122–3, f. 2 (h) (No Sg), t: Peradeniya, Ceylon; Hakgalla, Ceylon (♂♀); Alex.: PJS, 44:363 (1931).
Dist: JAPAN (Hokkaido); INDIA; CEYLON.

E. (E.) orientalis Brun., 1912: FBI, 449, 453–4 (No Sg), t: Darjiling, India; Kurseong, India; Shanghai, South China (♂♀); RIM, 17:237–8 (No Sg) (1920); Wu: CIS, 5:51 (1939); Alex.: RIM, 50:356 (1953); PJS, 82:73 (1953).
dictenidia Alex., 1921: AESA, 14:115–6, t: Shibuya; Keijo, Corea (♂♀).
Dist: JAPAN (Honshu; Shikoku); KOREA; CHINA; S. ASIA.

Subgenus **METERIOPTERA** Alex., 1934

Meterioptera Alex.: PJS, 53:462–3, 464, I:23–4 (w), III:42 (a), 43–5 (h) [*Erioptera*].
Type: *Erioptera javanensis* Meij.

E. (M.) insignis Edw., 1916: AM, (8)18:251–2 (Sg *Erioptera*), t: Arisan, Formosa; Tokyo, Japan (♂♀); Brun.: RIM, 17:238 (Sg *Erioptera*) (1920) [comb. nov.]†.
Dist: JAPAN (Honshu); FORMOSA.

Subgenus **HOPLOERIOPTERA** Alex., 1953

Hoploerioptera Alex.: PJS, 82:171 [*Erioptera*].
Type: *Erioptera* (*H.*) *shikokuensis* Alex.

E. (H.) honshuensis Alex., 1958: PJS, 86:323–4, VII:52 (w), VIII:60 (h), t: Mt. Amakazari, Echigo, alt. 900 m. (♂♀).
Dist: JAPAN (Honshu).

E. (H.) luctuosipes Alex., 1953: PJS, 82:172–3, IV:25 (w), 26 (h), t: Nisigawa to Yanase, Tosa, alt. 600 m.; Kokusen, near Yanase, Tosa, alt. 500 m. (♂♀).
Dist: JAPAN (Shikoku).

E. (H.) shikokuensis Alex., 1953: PJS, 82:171–2, IV:23 (w), 24 (h) (Sg *Horploerioptera*!), t: Mt. Tsurugi, Awa, Minokosi, alt. 1,400 m. to Nagoro, 900 m. (♂♀).
Dist: JAPAN (Shikoku).

Subgenus **TASIOCERODES** Alex., 1956

Tasiocerodes Alex.: JNES, 64:143, 144 [*Erioptera*]; PJS, 86:321 [*Erioptera*] (1958).
Type: *Erioptera* (*T.*) *persessilis* Alex.

E. (T.) persessilis Alex., 1958: PJS, 86:321–2, VII:53 (w), VIII:61 (h), t: Kurokawa, Echigo (♂); JNES, 64:144 (1956) [nom. nud.].
Dist: JAPAN (Honshu).

Genus **TASIOCERA** Skuse, 1890

Tasiocera Skuse: PLSN, (2)4:815–6; Alex.: *Mem. Queensl. Mus., 7:1 (1920); AM, (9)18:169–71 (1926); Edw.: JMM, 14:99 (*Taseocera*!) (1928).
Type: *Tasiocera tenuicornis* Skuse

Subgenus **DASYMOLOPHILUS** Goetg., 1920

Dasymolophilus Goetg.: *Bull. Soc. ent. Belg., 2: 132 [*Molophilus*]; Pierre: FF, 8:91, 98 (1924); Alex.: PJS, 36:478 (1928); FG, 50 (1934); PJS, 60:200 (1936) [key to Palaearctic spp.]; BCSS, 64:425, 475–6 [*Tasiocera*] (1942); End.: TM, 19 (1936); Wu: CIS, 5:50 [*Tasiocera*] (1939); Lacks.: ANMW, 50:11 [*Molophilus*] (1940); Coe: HIBI, 47, 66 [*Tasiocera*] (1950).
Type: *Erioptera murina* Meig.

T. (D.) kibunensis (Alex., 1936): PJS, 60:200–1, III:43 (h) [*Dasymolophilus*], t: Kibune, Kyoto, Honshiu, Japan; Arisan, Formosa (♂).
Dist: JAPAN (Honshu); FORMOSA.

Genus **MOLOPHILUS** Curt., 1833

Molophilus Curt.: *Brit. Ent., 444; O. S.: MD, 4: 152–3, 162 [*Erioptera*] (1869); BEZ, 31:192–3 (1887); Skuse: PLSN, (2)4:803–4 (1890); Kert.: KPD, 1:291–3 (1903); Coq.: PUNM, 37:571 (1910); Brun.: FBI, 438, 443–4 (1912); RIM, 17: 236 (1920); Alex.: PUNM, 44:492, 510 (1913); MCAS, 25:902, 906–7 (1919); PUNM, 58:416, 419–20 (1920) (with McAtee); MCAS, 38:909, 910, 911–2 (1920) [L; P]; PLSN, 54:137–8 (1929) [key to groups]; PJS, 48:631–2 (1932); FG, 51 (1934); BCSS, 64:425, 476–8 (1942); Pierre: FF, 8:91, 98, 142, f. f (L), f¹ (P) (1924); End.: TM, 20, f. 27 (w) (1936); Wu: CIS, 5:56–8 (1939); Lacks.: ANMW, 50:10–4 (1940) [k]; Coe: HIBI, 47, 61–5 (1950).
Type: *Erioptera atra* Meig. (as *brevipennis*, sp.

nov.).

Erioptera Rond., 1856: PDI, 1:179; Schin.: WEM, 7:221 (1863); FA, 2:xxvii, 541-2 (1864); O. S.: MD, 4:149-50 (1869); BEZ, 31:231 (1887) [nec Meig., 1803].

Type: *Erioptera obscura* Meig.

Subgenus **MOLOPHILUS,** s. str.

M. (M.) albohalteratus Alex., 1924: AESA, 17: 435 (*albohalterata*!), t: Mt. Takao, Musashi, alt. 1,000-2,000 ft. (♂♀); PJS, 42:508 (*albohalterata*!) (No Sg) (1930); PJS, 82:173 (1953).
Dist: JAPAN (Honshu; Shikoku; Kyushu).

M. (M.) apicidentatus Alex., 1954: PJS, 83:301-2, IV:45 (h), t: Omogo Valley, Iyo, alt. 800 m. (♂♀).
Dist: JAPAN (Shikoku).

M. (M.) babanus Alex., 1957: PJS, 85:382-3, IV: 42 (h), t: Kurokawa, Echigo (♂♀).
Dist: JAPAN (Honshu).

M. (M.) daimio Alex., 1953: PJS, 82:173-5, IV: 27 (h), t: Imanoyama, Tosa, alt. 800 m.; Kokusen, near Yanase, Tosa, alt. 500 m. (♂♀).
Dist: JAPAN (Shikoku).

M. (M.) diferox Alex., 1958: PJS, 86:325-6, VIII: 64 (h), t: Kurokawa, Echigo, alt. 200 m. (♂).
Dist: JAPAN (Honshu).

M. (M.) efferox Alex., 1947: AESA, 40:370-1, t: Kamikochi, Shinano, alt. 5,000 ft. (♂).
Dist: JAPAN (Honshu).

M. (M.) ferox Alex., 1931: PJS, 44:365, II:45 (h) (No Sg), t: Norikuradake, Japanese Alps, Shinano (♂); AESA, 40:371 (1947); PJS, 82:177 (1953); PJS, 82:305 (1954) [n]; PJS, 83:302 (1954) [n].
Dist: JAPAN (Honshu; Shikoku).

M. (M.) ishizuchianus Alex., 1954: PJS, 82:304-5, V:52 (h), t: Joju, Mt. Ishizuchi, alt. 1,400 m. (♂); TSES, 3:83 (1953) [nom. nud.].
Dist: JAPAN (Shikoku).

M. (M.) itoanus Alex., 1953: PJS, 82:73-4, II:30 (h), t: Mt. Tsurugi, Sugeoi, Awa (♂).
Dist: JAPAN (Shikoku).

M. (M.) iyoanus Alex., 1953: PJS, 82:175-6, IV: 28 (h), t: Okadamura, Iyo (♂).
Dist: JAPAN (Shikoku).

M. (M.) kiushiuensis Alex., 1940: PJS, 73:416-7, I:24 (w), V:50 (h), t: Fugandake, alt. 2,500 to 4,360 ft. (♂♀); PJS, 86:327, VIII:65 (h) (1958).
Dist: JAPAN (Honshu; Kyushu).

M. (M.) nakamurai Alex., 1933: PJS, 51:403-4, I:23 (w), IV:52 (h) (No Sg), t: Mt. Shirouma, Shinano (♂♀).
Dist: JAPAN (Honshu).

M. (M.) nesioticus Alex., 1953: PJS, 82:176-7, IV:29 (h), t: Mt. Tsurugi, Otiai, Awa (♂).
Dist: JAPAN (Shikoku).

M. (M.) nocticolor Alex., 1953: PJS, 82:177-8, IV:30 (h), t: Totidani, near Yanase, alt. 350 m.; Nisigawa, near Yanase, alt. 900 m. (♂♀).
Dist: JAPAN (Shikoku).

M. (M.) okadai Alex., 1936: PJS, 60:201-2, I:24 (w), III:45 (h) (No Sg), t: Sapporo, Ishikari (♂♀).
Dist: JAPAN (Hokkaido).

M. (M.) paucispinus Alex., 1957: PJS, 85:385-6, IV:41 (h), t: Kurokawa, Echigo (♂).
Dist: JAPAN (Honshu).

M. (M.) pegasus Alex., 1913: CE, 45:291-3, III: 11 (w), X:3-4 (h) (No Sg), t: Tokio (♂♀); PJS, 42:508 (No Sg) (1930); TSES, 3:83 (1953).
Dist: JAPAN (Honshu; Shikoku; Kyushu).

M. (M.) perferox Alex., 1957: PJS, 85:383-4, IV:43 (h), t: Kurokawa, Echigo (♂).
Dist: JAPAN (Honshu).

M. (M.) perflaveolus Alex., 1918: CE, 50:160-1 (No Sg), t: Fieldbrook, California, U. S. A. (♂); PJS, 86:327 (1958).

auricomus Alex., 1926: IIM, 14:115-7 (No Sg), t: Allardt, Buffalo-Cove, alt. 1,400 ft. & Crooked Creek, alt. 1,550 ft., Fentress Co., Tennessee, U. S. A. (♂♀); BCSS, 64:477, 478, f. 55B (h) (No Sg) (1942).
Dist: JAPAN (Honshu); N. AMERICA.

M. (M.) polycanthus Alex., 1936: PJS, 59:254-5, I:24 (w), II:38 (h) (No Sg), t: Kibune, Kyoto (♂♀); PJS, 82:74 (1953); PJS, 86:327-8, VIII: 66 (h) (1958).
Dist: JAPAN (Honshu).

M. (M.) sericatus Alex., 1925: AM, (9)15:68-9 (No Sg), t: Jozankei, Ishikari, alt. 1,000 ft. (♀).
Dist: JAPAN (Hokkaido).

M. (M.) takaoensis Alex., 1933: PJS, 51:404-5, I:24 (w), IV:53 (h) (No Sg), t: Mt. Takao, Musashi (♂); PJS, 82:178 (1953).
Dist: JAPAN (Honshu; Shikoku).

M. (M.) triacanthus Alex., 1934: PJS, 53:294-5, I:21 (w), III:41 (h) (No Sg), t: Yumoto, Shimotsuke, alt. 4,850 ft. (♂); PJS, 71:70 (1940); PJS, 83:303 (1954).

ssp. **triacanthus** Alex., 1934
Dist: JAPAN (Honshu; Shikoku); N. KOREA.

ssp. **debilispinus** Alex., 1957: PJS, 85:385 (*triacanthus*, ssp.), t: Yoshikiya, Shinano, alt. 1,500 m. (♂♀).
Dist: JAPAN (Honshu).

M. (M.) trifilatus Alex., 1920: TAES, 46:9-10 (No Sg), t: Meguro, Tokio (♂♀); PJS, 83:305 (1954) [n].
Dist: JAPAN (Honshu; Shikoku).

Genus **STYRINGOMYIA** Loew, 1845

Styringomyia Loew: *Dipt. Beitr., 1:6; Big.:

ASEF, (3)2:472 (1854); O. S.: MD, 4:102-3 (1869); MD, add., VII (1873); BEZ, 31:185-6 (1887); BRUN.: RIM, 6:297 (1911); FBI, 439, 459-61, f. 39-10 (w) (1912); RIM, 15:304 (1918); RIM, 17:244-6 (1920); EDW.: TES, 1914:206-27, pls. XIX-XXV (1914) [key to spp.]; AM, (9)13: 265-74 (1924); ALEX.: MCAS, 38:957-8 (1920); PJS, 46:294-5 (1931); FG, 49 (1934); WU: CIS, 5:60 (1939).

Type: *Styringomyia venusta* LOEW

Idiophlebia GRÜNBERG, 1903: ZA, 26:524-7.

Type: *Styringomyia didyma* GRIMSHAW (as *pallida*, sp. nov.).

Pycnocrepis END., 1912: ZJ, 32:65.

Type: *Styringomyia crassicosta* SPEISER (as *annulipes*, sp. nov.).

Mesomyites COCKERELL, 1917: PUNM, 52:377.

Type: *Mesomyites concinnus* COCKERELL

S. formosana EDW., 1914: TES, 1914:211, 219-20, XIX:9 (abdominal markings of ♂), XXI:30-1 (h), XXV:70-2 (tip of ♀ abdomen), t: Tainan, Formosa; Koshun, Formosa (♂♀); BRUN.: RIM, 17:245 (1920); ALEX.: PJS, 40:346 (1929).

annulipes (RIED., 1912): Suppl. Ent., 1:26-7, f. (h) [*Pycnocrepis*] [nec END., 1912].

crassicosta RIED., 1913: Ent. Mitt., 2:272 [nec SPEISER, 1908].

Dist: JAPAN (Honshu); FORMOSA.

S. nipponensis ALEX., 1929: PJS, 40:345-6, III:41 (h), t: Asahara, Honshiu (♂); TSES, 3:83 (1953).

Dist: JAPAN (Honshu; Shikoku); FORMOSA.

SUPPLEMENT (1)

Acknowledgement

I wish to express my hearty thanks to Drs. K. YASUMATSU, Y. HIRASHIMA, and T. HIDAKA (Kyushu Univ.) for their kind aids in literature.

List of Abbreviations (III)

CIIJ:- Coloured illustrations of the insects of Japan. Orthoptera, Odonata, Hemiptera, Neuroptera, Lepidoptera, Hymenoptera & Diptera. Hoikusha, Osaka; FPR:- in LINDNER, Die Fliegen der palaearktischen Region; GI:- Genera Insectorum; ICIJ:- Illustrated common insects of Japan. IV. Hymenoptera, Diptera, Rhynchota. Shunyôdô, Tokyo; KS:- Kenkyû Shûroku (Annual reports of the Hyogo Agricultural College); Ms:- Mushi, Fukuoka.

F.:- FABRICIUS; L.:- LINNÉ; MANNH.:- MANNHEIMS; PORTSCH.:- PORTSCHINSKY; TAKAH.:- TAKAHASHI; TAKEU.:- TAKEUCHI; THEOB.:- THEOBALD.

Add:- Addition to distribution; Del:- Delete previous citation in KS; redes:- redescription.

Misprints or errors in preceding parts express in bold face type (except in scientific names).

Subfamily **TIPULINAE**

Tribe **CTENOPHORINI**

Genus **CTENOPHORA** MEIG., 1803

Ctenophora MEIG.: *l. c.; *SB, 1:XVI, 155 [XXII, 123-4] (1818); LATR.: *Consider. Général., 442 (1810) [type as *Tipula atrata* L.]; WIED.: Dipt. Exot., 19 (1821); MACQ.: HNI, 1:77-8 (1834); WESTW.: *Intr., 2, Synops., 128 (1840) [type as *Tipula pectinicornis* L.]; ZETT.: DS, 10:4010-2 (1851); BIG.: ASEF, (3)2:469 (1854); ROND.: PDI, 1:187 (1856) [type as *C. flaveolata* F.]; SCHIN.: FA, 2:XXVI, 498-502 (1864); O. S.: BEZ, 30:164-5, 167-8, 173-5 (1886); KERT.: KPD, 1:324-5 (1903); COQ.: PUNM, 37:529 (1910) [type as *Tipula atrata* L.]; BRUN.: RIM, 6:235-6 (1911); FBI, 288-9 (1912) [type as *Tipula atrata* L.]; RIM, 17:187-8 (1920) [type as *Tipula flaveolata* F.]; ALEX.: MCAS, 25:930, 931-2 (1919); PUNM, 58: 394 (1920) (with MCATEE); MCAS, 38:977, 986 (1920) [L; P]; FG, 37 (1934); PJS, 60:167, 168 (1936); ECSS, 65:209, 218 (1942); PJS, 83:264-5 (1954) [type as *pectinicornis* L.]; PIERRE: FF, 8:19, 20-2 (1924); GI, 186:8, 52-3 (1926) [type as *C. pectinicornis* L.]; END.: TM, 26, f. 58 (♂ a) (1936); WU: CIS, 5:20 (1939); COE: HIBI, 7-8 (1950); ISHIDA: KS, 4:109, 111-3 (1955) [type as *Tipula flaveolata* F.]; TAKAH.: Ms, 34:101, 103, 111-2 (1960) [k & key to spp.].

Type: *Tipula pectinicornis* L.

Flabellifera MEIG., 1800: *l. c.; HENDEL: *VZBG, 58:45 (1908); COQ.: PUNM, 37:545 (1910) [type as *Tipula atrata* L.]; END.: ZJ, 32:22-3 (1912) [type as *F. pectinicornis* L.]; MANNH.: FPR, 15: 19, 28-9 (1951) [type as *pectinicornis* L.]; THEOB.: TE, 100:212, 213 (1957) [L; P].

Type: *Tipula pectinicornis* L.

Cnemoncosis END., 1921: l. c.; ALEX.: PJS, 82:41 (1953).

Subgenus **DICTENIDIA** BRULLÉ, 1833

Dictenidia BRULLÉ: *l. c.; BIG.: ASEF, (3)2:469-70 (1854); O. S.: BEZ, 30:166, 173-4 (1886); KERT.: KPD, 1:321-2 (1903); END.: ZJ, 32:25 (1912); TM, 25 (1936); ALEX.: MCAS, 38:987-8 (1920) [L; P]; PJS, 83:265 [*Ctenophora*] (1954); PIERRE: FF, 8:18-9 (1924); WU: CIS, 5:20-1 (1939); COE: HIBI, 6, 7 (1950); MANNH.: FPR, 15:19, 25 (1951); THEOB.: TE, 100:212, 213 (1957) [L; P].

Ceroctena ROND., 1856: l. c.

Type: *Tipula bimaculata* L.

Dicera LIOY, 1863: *Atti **Ist.** Veneto, (3)9:216.

Type: *Tipula bimaculata* L.

C. (D.) miyatakei (ALEX., 1953): l. c. (♂).

C. (D.) pictipennis PORTSCH., 1887: l. c., I:1 (**w**), t: **Wladiwostok,** Amur (♀); WU: CIS, 5:21

〔*Dictenidia*〕 (1939).

semifasciata (Alex., 1925): l. c., t: Nakakebo, Hitaka; Sarabuto, Hitaka (♂); Masaki: Ms, 6:93 (*fasciata*, ssp.) 〔*Dictenidia*〕 (1933).

ssp. **pictipennis** Portsch., 1887

Add: JAPAN (Honshu).

ssp. **fasciata** (Coq., 1898): l. c. (♂♀); Mats.: Nippon Konchûgaku, 129, f. 100 (♀)〔*Dictenidia*〕 (1898); 6000, p. 393, f. 249 (♂) 〔*Dictenidia*〕 (1931); ICIJ, 4:37 (In Jap.) & 53 (In Eng.), X:1 (♂) 〔*Dictenidia*〕 (1932); Kert.: KPD, 1:322 〔*Dictenidia*〕 (1903); Alex.: AESA, 13:262 〔*Dictenidia*〕 (1920) 〔n〕; PJS, 73:381 (*pictipennis*, ssp.) 〔*Dictenidia*〕 (1940); PJS, 82:41 (*pictipennis*, ssp.) 〔*Dictenidia*〕 (1953); Esaki: IIJ, 176, f. 341 (♂) 〔*Dictenidia*〕 (1932); l. c., f. 4391 (♂), XV:3 (♂) (1950); Masaki: Ms, 6:93 〔*Dictenidia*〕 (1933); Shir.: CI, 645, f. 1205 (♂) 〔*Dictenidia*〕 (1954); Takeu.: CIIJ, 143, LXIII:1016 (♂) 〔*Dictenidia*〕 (1955).

Add: KOREA.

Nom. Jap.: *Bekkô-gagambo* (Mats.).

Subgenus **TANYPTERA** Latr., 1804

Tanyptera Latr.: *l. c.〔according to Stone, p. 188; Takah., p. 423〕; *Hist. Nat. Crust. et Ins., 14:286 (1805); Coq.: PUNM, 37:612 (1910); Alex.: MCAS, 25:930, 931 (1919); PUNM, 58:394 (1920) (with McAtee); MCAS, 38:977, 988 (1920) 〔L; P〕; FG, 37 (1934); BCSS, 64:209, 218 (1942); PJS, 83:265 〔*Ctenophora*〕 (1954); Pierre: FF, 8:19, 20 (1924); GI, 186:8, 51–2 (1926); End.: TM, 25 (1936); Wu: CIS, 5:23 (1939); Stone: AESA, 34:410 (1941); Coe: HIBI, 7–8 (1950); Mannh.: FPR, 15:19, 26 (1951); Theob.: TE, 100:211, 213 (1957) 〔L; P〕; Takah.: Ms, 33:10, 17 (1960) 〔key to spp.〕.

Xiphura Brullé, 1832: *l. c.; Macq.: 1:79 (1834); Big.: ASEF, (3)2:470 (1854); Rond.: PDI, 1:186–7 (*Xyphura*!) (1856); O. S.: BEZ, 30:166–7, 173–5 (1886); Kert.: KPD, 1:322–4 (1903); Coq.: PUNM, 37:621 (1910); End.: ZJ, 32:23–4 (1912); Brun.: RIM, 17:187 (1920).

Mesodictenidia Mats., 1931: l. c.; Alex.: PJS, 83: 265 (1954).

Type: *Mesodictenidia macraeformis* Mats.

C. (T.) angustistyla (Alex., 1924): l. c., t: Mt. Moiwa, Ishikari (♂); PJS, 59:226 (1936); Takah.: Ms, 33:15, 17, II:7 (w), III:6, 12, 18 (h) 〔*Tanyptera*〕 (1960).

Add: JAPAN (Honshu).

C. (T.) brevipecten (Alex., 1955): AESA, 48: 364–5, f. 1 (w) 〔*Tanyptera*〕, t: Naidaizin, alt. 700 m.; Kunimidake, alt. 1,200 m. (♂); Takah.: Ms, 33:16, 17 〔*Tanyptera*〕 (1960).

Dist: JAPAN (Kyushu).

C. (T.) flavoposticata (Alex., 1954): TSES, 4: 24–5 〔*Tanyptera*〕, t: Omogo Val., alt. 700 m. (♂♀); PJS, 83:266, I:3 (w), 4 (h) (1954); Takah.: Ms, 33:14, 17, II:3 (w) 〔*Tanyptera*〕 (1960).

Dist: JAPAN (Honshu; Shikoku).

C. (T.) fumibasis (Alex., 1925): AM, (9)**15**:392 (*jozana*, ssp.) 〔*Tanyptera*〕, t: Chichibu, Musashi (♂); PJS, 82:44 (*jozana*, ssp.) 〔*Tanyptera*〕 (1953); Esaki: IIJ, 175 (*jozana*, f.) 〔*Tanyptera*〕 (1932); IIJ, ed. 2, 1530 (*jozana*, f.) 〔*Tanyptera*〕 (1950); Masaki: Ms, 6:93 (*jozana*, ssp.) 〔*Tanyptera*〕 (1933); Takah.: Ms, 33:11–2, 17, II:4 (w), III:3, 8, 14 (h) 〔*Tanyptera*〕 (1960).

Add: JAPAN (Kyushu).

C. (T.) jozana (Mats., 1916): l. c., t: Jozankei, near Sapporo (♀); 6000, p. 398, f. 268 (♀) 〔*Xiphusa*!〕 (1931); Alex.: PJS, 24:596 〔*Tanyptera*〕 (1924) 〔var.〕; PJS, 60:174 〔*Tanyptera*〕 (1936) 〔s. str.〕; Esaki: IIJ, 175, f. 340 (♂) 〔*Tanyptera*〕 (1932); l. c., f. 4390 (♂) (1950); Masaki: Ms, 6:93 〔*Tanyptera*〕 (1933); Wu: CIS, 5:23 〔*Tanyptera*〕 (1939); Takeu.: CIIJ, 143, LXIII:1018 (♂)〔*Tanyptera*〕 (1955); Takah.: Ms, 33:10–1, 17, II:1 (w), III:1, 7, 13 (h) 〔*Tanyptera*〕 (1960).

ssp. **jozana** (Mats., 1916)

Add: SAKHALIN; KOREA.

Nom. Jap.: *Haranaga-kushihige-gagambo* (Esaki); *Jôzan-kushihige-gagambo* (Mats.).

C. (T.) kotan (Takah., 1960): Ms, 33:12–3, 17, II: 5 (w), III:4, 9, 15 (h) 〔*Tanyptera*〕, t: Ashorobuto, Ashoro Gun; Osappe, Lakeside of Kutcharo (♂♀).

Dist: JAPAN (Hokkaido).

C. (T.) macraeformis (Mats., 1931): 6000, p. 395, f. 257 (♂) 〔*Mesodictenidia*〕, t: Sapporo (♂); ICIJ, 4:37 (In Jap.) & 53–4 (In Eng.), X:4 (♂) 〔*Mesodictenidia*〕 (1932); Alex.: PJS, 82:43 〔*Tanyptera*〕 (1953) 〔as synonym of *jozana*〕; Takah.: Ms, 33:13–4, 17, II:2 (w), III:2, 10, 16 (h) 〔*Tanyptera*〕 (1960).

macra (Mats., 1905): l. c.; J. Coll. Agric. Tohoku Imp. Univ., 4:62 〔*Xiphusa*!〕 (1911) 〔nec Loew, 1873〕.

Dist: JAPAN (Hokkaido); SAKHALIN.

Nom. Jap.: *Seguro-kushihige-gagambo* (Mats.).

C. (T.) perangusta (Alex., 1953): l. c., t: Iwai, near Imanoyama, Tosa, alt. 200 m. (♂♀); Takah.: Ms, 33:16, 17, II:8 (w) 〔*Tanyptera*〕 (1960).

Add: JAPAN (Kyushu).

C. (T.) tsurugiana (Takah., 1960): Ms, 33:15–6, 17, II:6 (w), III:5, 11, 17 (h) 〔*Tanyptera*〕, t: Mt. Tsurugi, Tokushima Pref. (♂).

Dist: JAPAN (Shikoku).

(*To be continued.*)

(Entomological Laboratory of Kakogawa Branch, Received Aug. 31, 1961).

ENERGY LEVELS OF Ir^{188}

Hiroshi MATSUI

The energy levels of Ir^{188} from the decay of Pt^{188} have been studied. Energies and intensities of conversion electrons have been studied with a sector-type double focusing beta-ray spectrometer and a thin lens beta-ray spectrometer. Relative gamma-ray intensities have been measured with scintillation spectrometers. Gamma-gamma coincidences have also been studied. Gamma transitions of energies 54.5, 140.3, 187.6, 195.0, 281.1, 381.5, 422.5 and 479 kev have been confirmed. Six new transitions of energies 114.5, 169, 240, 250, 291 and 308 kev have also been observed. On the basis of K/L ratios, L-subshell ratios and conversion coefficients, multipolarities have been assigned to the transitions as follows: 54.5 and 140.3 kev, M1+E2; 187.6 and 195.0 kev, M1; 281.1, 381.5 and 422.5 kev, probably E1. A decay scheme is proposed.

1. INTRODUCTION

The odd-odd nuclei are of increasing interest, since they provide useful information on the effective interaction between protons and neutrons in nuclear matter. The experimental data on the odd-odd nuclei, however, are very poor and only the ground and some isomeric states have been discussed in the recent theoretical studies.[1)-4)] It is desirable to accumulate more experimental information on the low-lying levels of odd-odd nuclei. In the present paper, the study of the energy levels of odd-odd Ir^{188} from the decay of Pt^{188} is described.

The 10.3-day Pt activity was first reported by Naumann[5)] and assigned to mass 188. Smith and Hollander[6)] confirmed the above assignment and observed the gamma-rays of energies 195, 275 and 400 kev with relative intensities 1.0, 0.1 and 0.3, respectively. Recently using scintillation coincidence and conversion electron spectroscopy, Fisher and Naumann[7)] studied the decay of Pt^{188}. They reported the transitions of energies 55, 140, 188.5, 195.7, 279, 382.0, 410 and 470 kev and $(279\gamma-196\gamma)$, (K X-ray $-188\gamma, 196\gamma$), and (L X-ray -382γ) coincidences. On the basis of these data, Way et al.[8)] proposed a tentative decay scheme in the Nuclear Data Sheets. But the relative electron intensities, transition multipolarities, level spins and parities have not been reported as yet.

In the present work, energies and intensities of conversion electrons were studied with a double focusing beta-ray spectrometer and a thin lens beta-ray spectrometer. Relative gamma-ray intensities were measured with scintillation spectrometers. Gamma-gamma coincidences were also studied. In addition to the previously reported transitions, six new weak transitions were observed. The multipolarities of seven strong transitions were determined on the basis of the observed K/L ratios, L_I+L_{II}/L_{III} ratios and K- or L-conversion coefficients. A decay scheme is proposed, which contains six excited levels with possible spins and parities and includes all the observed transitions.

2. EXPERINENTAL PROCEDURES

The 10.3-day Pt^{188} was produced by the Ir^{191} $(p, 4n)Pt^{188}$ reaction. The 99.9% natural Ir was bombarded with 55 Mev protons in the synchro-cyclotron of the Institute for Nuclear Study of the University of Tokyo. The carrier-free Pt sources were prepared by chemical separation about ten days after bombardment. At that time, the relatively short-lived activities decayed sufficiently and only 10.3-day Pt^{188}, 3.0-day Pt^{191} and 41-hr Ir^{188} (daughter of Pt^{188}) were present in these sources. These sources, refered to as type A, were mostly used in both the conversion electron and scintillation measurements because of their strong intensity. The radiations of Ir^{188} were easily distinguished from those of Pt^{188} and Pt^{191} by their increases in intensity due to the growth of Ir^{188} in the freshly prepared sources. To distinguish the radiations of Pt^{191} from those of Pt^{188}, the other Pt sources, refered to as type B, were also prepared by chemical separation about a month after bombardment. These sources were free from Pt^{191} impurities, but their intensities were rather weak. The type B sources were used in the measurement with the thin lens spectrometer and in the relative gamma-ray intensity measurement. To check the possible Ir^{189} (10-day) contamination in both types of Pt

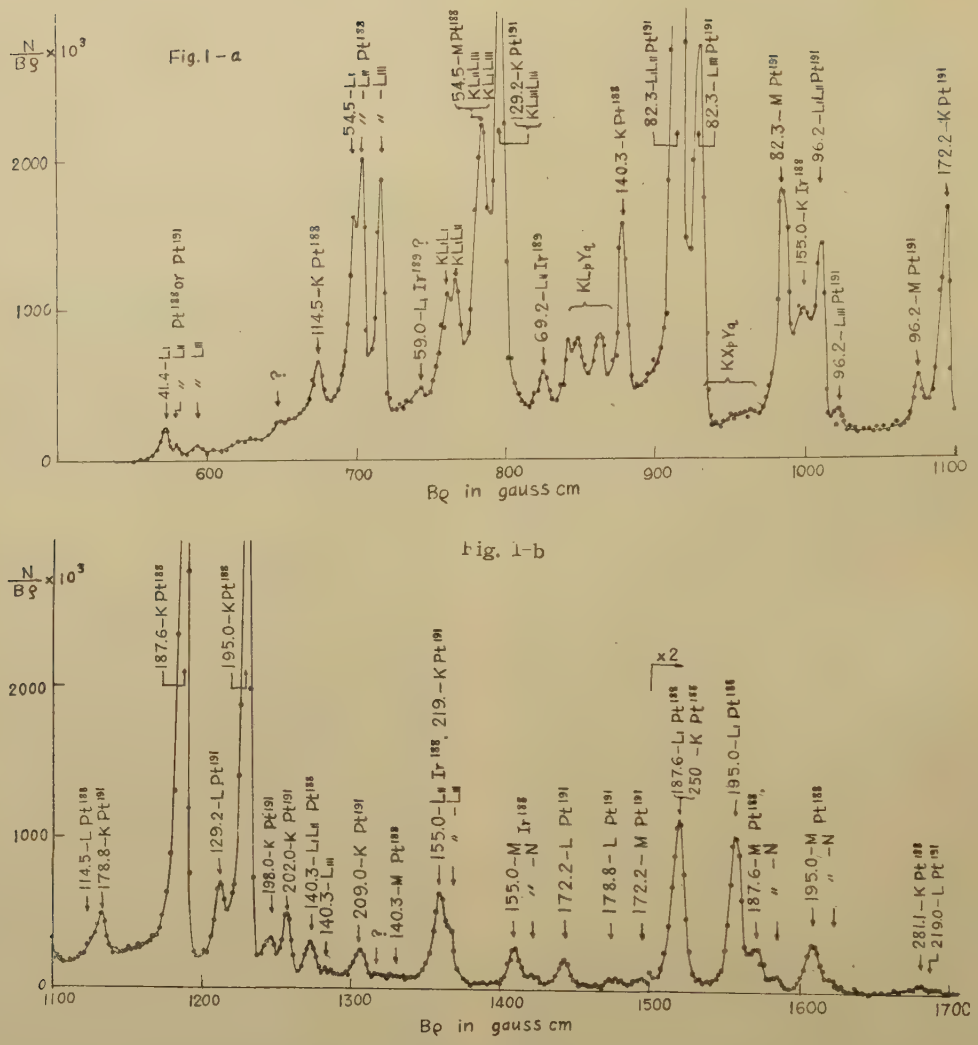

Fig. 1. Conversion electron spectrum obtained with double focusing spectrometer. Resolution: 0.7%. Source: Type A.

sources, the Ir sources were prepared by "milking" the daughter Ir fraction from the initially separated Pt fraction. It was found that practically no Ir^{189} were present in the Pt sources, since the strongest L-conversion lines of the 69.5 kev transition from the decay of Ir^{189} were scarecely observed.

Conversion electrons in the energy range 30 to 500 kev were studied mostly with a sector type double focusing beta-ray spectrometer with $\rho=18$ cm.[9) 10)] The very thin sources for electron measurement were successfully prepared by 5 to 30 minutes electroplating from the carrier free Pt fraction onto 5μ nickel backings. With a 3 mm by 20 mm source the momentum resolution of about 0.7% was obtained above 100 kev, and 0.8 to 1.0% in the range 30 to 80 kev. A G-M counter with a 0.6 mg/cm^2 mica window was used as the detector. Corrections for the counter window absorption were made using the transmission curve given by Lane and Zaffarano[11)] for the Formvar films of 0.63 mg/cm^2.

Two sources of type A with different strengths were used. For each source two or three runs were performed for several days. The spectrum obtained was very complex due to the Pt^{191} contamination and more than 80 lines including K Auger electron lines were observed. A typical electron spectrum is shown in Fig. 1. The energies of the lines were determined relative to the K and L_{II} lines of the 155.0 kev transition in the

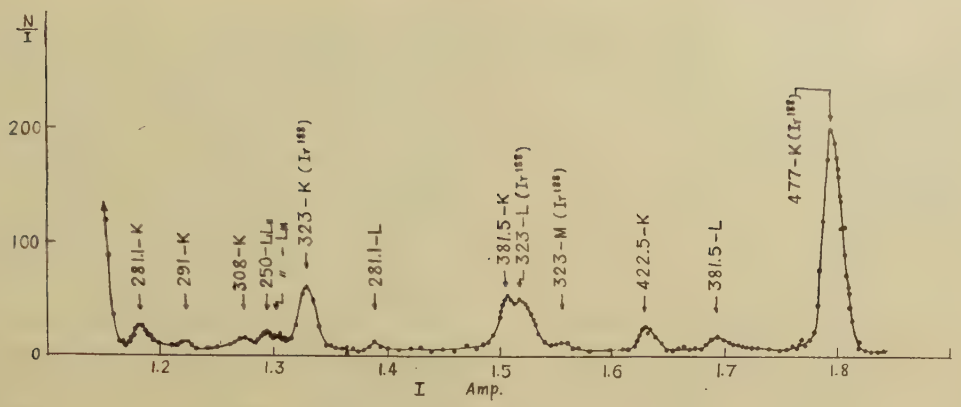

Fig. 2. Conversion electron spectrum obtained with thin lens spectrometer. Resolution: 1%. Source: Type B.

decay of Ir^{188}, which were measured with the high resolution (0.1%) permanent magnet spectrographs by Diamond and Hollander.[12]

The relative intensities of the conversion lines were determined by comparing the areas of the different lines. If the effects of source thickness and backscattering are negligible, all lines are expected to have a same line profile.* Then the spectrum should be consistently unfolded by the successive subtraction method using the "same" line profile for all lines. The large part of the line profile used was determined by comparing the relatively well resolved lines of the 187.6 kev-K, 195.0 kev-K and 187.6 kev-L_I conversion electrons. Since the shape of the tail was not shown clearly in the observed spectrum, it was determined by trial and error. By this procedure, about thirty lines above 100 kev could be successfully resolved. This procedure reduced largely the errors in evaluating the line areas and further made the existences of the very weak lines more reliable. In the region below 100 kev, it was necessary to take account of the variation of the line profile with energy due to the effects of source thickness and backscattering. This, together with the cemplexity of the spectrum due to the K Auger electron lines, made it rather difficult to analyze the spectrum below 100 kev. Thus the intensity errors of the lines in this energy region were somewhat larger than those above 100 kev.

Almost all the lines observed with the type A sources were assigned to the decays of Pt^{188}, Pt^{191} and Ir^{188}. In assigning the lines, the observed half-life of each line as well as the results of the earlier works[7),8),12),13] were refered. The above assignments were confirmed with certainty in the following measurements with the type B sources.

The type B sources were used in the thin lens spectrometer[14] measurements a month after bombardment to study the weak lines in detail. Since the electron sources were prepared by electroplating for many hours to obtain sufficiently high intensities, the source thickness became large and the lines below 200 kev could not be sufficiently resolved. The resolution was about 1% above 200 kev. A typical spectrum above 200 kev is shown in Fig. 2. Several weak lines appeared clearly, which had been hidden by the strong Pt^{191} lines in the measurement with the type A source.

Relative gamma-ray intensities were measured with a type B source using a 3 in.×3 in. NaI detector coupled to a DuMont 6363 photomultiplier in conjunction with a RCL 256 channel analyzer.* A gamma-ray spectrum obtained immediately after chemical separation is shown in Fig. 3. Since the strongest 155 kev gamma-ray from the decay of Ir^{188} are scarecely observed, the spectrum is considered to be of pure Pt^{188}. The source-to-crystal distance is 16.5 cm. The spectrum shapes for the particular energy gamma-rays were obtained by interpolation and extrapolation of the standard spectra of the monoenergetic gamma-rays of Cs^{137} (662 kev), Na^{22} (511 kev), Cr^{51} (322 kev), Hg^{203} (239 kev) and In^{114} (191 kev) observed in this spectro-

* "Line profile" used in this paper means the diagram having N/N_{peak} as ordinate and p/p_{peak} as abscissa, where N is the counts per unit momentum and unit time, p is the momentum, and N_{peak} and p_{peak} are the values at the peak position. Then the line profile for monoenergetic electrons becomes energy-independent.

* The author would like to thank Professor S. Shimizu of Kyoto University for allowing the use of this spectrometer.

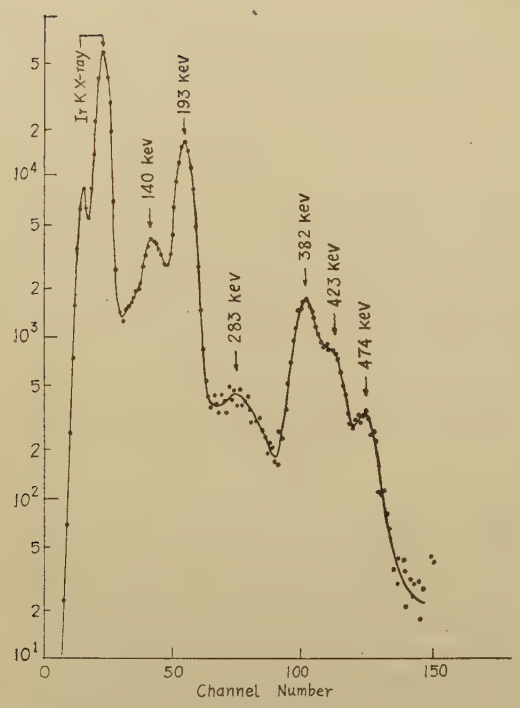

Fig. 3. Gamma-ray spectrum of Pt^{188}.

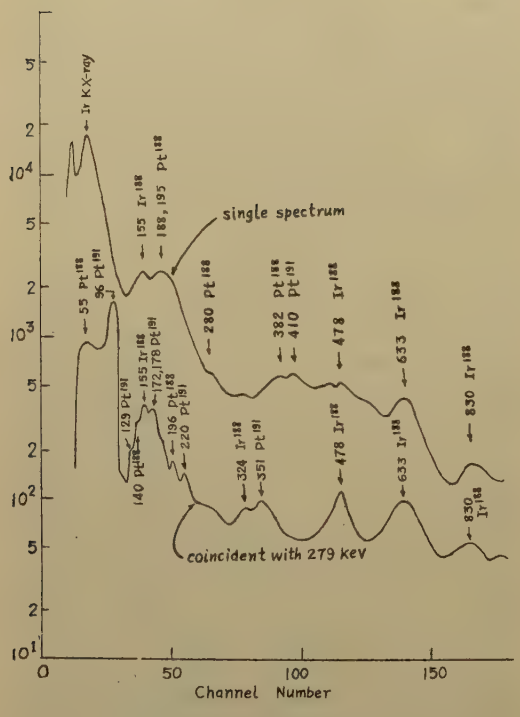

Fig. 4. Gamma-ray spectrum in coincidence with the 279 kev peak.

meter under the same conditions. Using these shapes, the spectrum was analyzed by the successive subtraction method. For the detection efficiencies of 3 in. × 3 in. crystal the values obtained at the Oak Ridge National Laboratory[15] were used.

Gamma-gamma coincidences were studied in a scintillation coincidence spectrometer[10] with a resolving time 6×10^{-8} sec. Two NaI crystals 1½ in. × 2 in. were coupled to RCA 6342 photomultipliers and shielded by the conical Pb shields. The spectra in coincidence with the 140, 188, 195 and 279 kev gamma-ray peaks were obtained with 20 channel analyzer. A typical spectrum in coincidence with the 279 kev peak is shown in Fig. 4 together with a single spectrum obtained in this spectrometer.

3. RESULTS AND DISCUSSIONS

3.1. Conversion electron and scintillation studies

Results obtained in the conversion electron measurements are summarized in Table I. The earlier results of Fisher and Naumann[7] are also given in the table. The errors of energy values were estimated from the differences between the values obtained with the double focusing spectrometer and those obtained with the thin lens spectrometer. All transitions reported by Fisher and Naumann were confirmed in this work. The energy values of these transitions agree well with those of Fisher and Naumann except 410 and 470 kev. In the present work, the 410 kev-K line was not observed but the 422.5 kev-K line was observed. Therefore, the energy value of 410 kev reported by Fisher and Naumann has been corrected to 422.5 kev. In the energy region about 470 kev, only the 477 kev-K line of Ir^{188} was observed. On the other hand, the scintillation spectrum showed clearly the existence of the gamma-ray of Pt^{188} of about 474 kev, whose intensity was rather strong so that its K-conversion line should appear in the electron spectrum. It is concluded, therefore, that the K-conversion line of this transition is hidden by the 477 kev-K line of Ir^{188}. The energy value of this transition is determined to be 479 kev, since the difference between the K-binding energy for Ir and that for Os is about 2 kev. The error of this energy value is estimated to be ±1 kev from the resolution of the spectrometer. In addition to the above transitions, six new weak transitions of energies 114.5, 169, 240, 250, 291 and 308 kev were observed.

The 41.4 kev-L_I, L_{II} and L_{III} lines and the 146.5 kev-K and L lines were also observed. The assignments of these lines to Pt^{188} are uncertain, although the energy sum of these transitions is 187.9 kev and coincides with the energy of the 187.6 kev

Table I
Results of the conversion electron study

Transition energy (kev)	Lines observed		K/L	$\frac{L_I+L_{II}}{L_{III}}$	Fisher and Naumann
	Shell	Intensity			Transition energy (kev)
54.5± .1	L_I, L_{II} L_{III}	47 33		1.42	55
114.5± .5 a)	K L	10 1.6±0.6	~6		
140.3± .2	K L_I, L_{II}, L_{III}	28.4±2 7.4±0.6	3.8±0.4	~5	140
169 ±1 a)	K	e)			
187.6± .2	K L_I b) M N	100 ±2 $17.6^{+0.7}_{-1.7}$ f) 4.9±0.4 1.7±0.4	$5.7^{+0.6}_{-0.3}$ f)	>50	188.5
195.0± .2	K L_I M N	92.6±2 15.6±1.2 6.0±0.5 1.8±0.4	6.0±0.5		195.7
240 ±1 a)	K	e)			
250 ±1 a)	$L_I L_{II}$, L_{III} c)	0.18			
281.1±1	K L	0.3 <0.07	>4		279
291 ±1 a)	K	<0.1			
308 ±1 a)	K	<0.1			
381.5±1	K L	0.53 <0.13	>4		382
422.5±1	K	0.22			410
479 ±1	d)				470

a) New transitions.
b) Composite with the possible K line of the 250 kev transition.
c) K line is possibly hidden by the L line of 187.6 kev transition.
d) Conversion lines are probably hidden by the lines of Ir^{188} 477 kev transition. See text.
e) Very weak.
f) The contribution from the possible K line of the 250 kev transition is not subtracted but included in the errors quoted.

transition.

Electron intensities, K/L ratios and L_I+L_{II}/L_{III} ratios have not been reported previously. In the present work, electron intensities have been obtained with the method described in § 2. The intensity errors introduced in subtracting the background contributions are believed to be very small. The main contribution to the errors is considered to be statistical. For the line intensities not derived with the above consistent method, the errors have not been estimated.

Energies and intensities of gamma-rays obtained in the scintillation study are given in Table II. The 193 kev peak is a composite peak of 187.6 and 195.0 kev. The 283 kev peak is also complex, since the observed half-width of this peak is twice as large as that of the single peak of the same energy. This is consistent with the result that five new transitions are observed in the energy range 240 to 308 kev in the conversion electron measurement.

Table II
Energies and intensities of the gamma-rays

Energy (kev)	Relative intensity		
	Present work	Smith and Hollander	N.D.S.
55			20
140	8.6		10
193 a)	100	100	100
283 b)	4	10	10
382	20		10
423	9.7	30	10
474	6.1		10

a) Composite peak of 187.6 and 195.0 kev.
b) Complex. See text.

The gamma-gamma coincidence spectrum was very complex due to the Pt^{191} and Ir^{188} contaminations. But the following coincidence pairs have been confirmed by a careful analysis: $(279\gamma-196\gamma)$, $(55\gamma-140\gamma)$, $(55\gamma-279\gamma)$ and $(140\gamma-279\gamma)$. Care was taken to confirm the new transitions observed in the electron measurement, and a slight indication for the existences of the 240, 250 and 290 kev gamma-rays was found. The results of gamma-gamma coincidence measurement are summarized in Table III.

3.2. Multipolarity assignment

Experimental and theoretical values of the K conversion coefficients, K/L and L_I+L_{II}/L_{III} are shown in Table IV. The theoretical values are deduced from Sliv's tabulations.[16] The multipolarity assignments are also shown in this table. The experimental values of the K conversion coefficients are obtained by comparing the relative electron and gamma-ray intensities using the K conversion coefficients of the 187.6 and 195.0 kev transitions as reference.

The 187.6 kev transition is either E1 or M1 from the experimental K/L ratio. The L_I+L_{II}/L_{III} ratio is estimated to be larger than 50. This indicates that this transition is almost pure M1 with a possible admixture of E2 smaller than 1%. The 195.0 kev transition is also either pure M1 or pure E1 from the experimental K/L ratio. The L_{III} line of this transition is hidden by the M-line of the 187.6 kev transition and the L_I+L_{II}/L_{III} ratio cannot be estimated. But, if the 195.0 kev transition is assumed to be E1, the K conversion coefficients of the 281.1, 381.5 and 422.5 kev transitions become so small that there are no corresponding multipolarities for these transitions. On the other hand, those calculated by assuming the M1 multipolarity for the 195.0 kev transition agree well with the values for E1. Therefore, it is concluded that the multipolarity of the 195.0 kev transition is M1. Since the 187.6 and 195.0 kev gamma-rays could not be resolved in the scintillation spectrum, their relative intensities were obtained from the relative electron intensities together with the assumption of M1 multipolarities for these transitions. These relative intensities were used to deduce the K conversion coefficients of the other transitions.

From the K/L ratio the 140 kev transition is assumed to be 70%M1+30%E2. The experimental values of L_I+L_{II}/L_{III} and K conversion coefficient are consistent with this M1+E2 admixture. The multipolarity of the 54.5 kev transition is assumed to be 70% M1+30% E2 from the experimental

Table III
Results of gamma-gamma coincidence measurement

Gamma-ray energy (kev)	55	140	188	196	240	250	279	291	382	423
140	○		×	×	△	×	○	×	×	
188	×	×		×	×	△	×	△		
196	×	×	×		△		○	×		
279	○	○	×	○				×		

○: Coincidence confirmed.
△: Slight indication for coincidence.
×: No coincidence.

Table IV
K conversion coefficients, K/L and L_I+L_{II}/L_{III}

Transition energy (kev)	Experimental			Theoretical				Multipolarity
	α_K	K/L	$\frac{L_I+L_{II}}{L_{III}}$		α_K	K/L	$\frac{L_I+L_{II}}{L_{III}}$	
54.5			1.42	E1			2.2	70% M1
				M1			96	+30% E2
				E2			1.0	
				M2			2.7	
140.3	1.4	3.8 ± 0.4	~5	E1	0.13	5.7	4.8	70% M1
				M1	1.9	6.0	110	+30% E2
				E2	0.48	0.6	1.5	
				M2	11	3.2	7.0	
187.6	(0.86)	$5.7^{+0.6}_{-0.3}$	>50	E1	0.064	5.9	6.0	M1
				M1	0.86	6.0	110	
				E2	0.20	1.1	1.8	
				M2	4	3.7	9.4	
195.0	(0.78)	6.0 ± 0.5		E1	0.058	6.0	6.1	M1
				M1	0.78	6.0	110	
				E2	0.17	1.3	1.0	
				M2	3.4	3.8	10	
281.1	0.023	>4		E1	0.025	6.1		E1
				M1	0.28	6.0		
				E2	0.072	2.0		
				M2	1.0	4.3		
381.5	0.011	>4		E1	0.012	6.3		E1
				M1	0.12	6.0		
				E2	0.032	2.9		
				M2	0.32	4.7		
422.5	0.0095			E1	0.0095			E1
				M1	0.095			
				E2	0.026			
				M2	0.24			

L_I+L_{II}/L_{III} ratio. Since the relative intensity of this gamma-ray and also the K conversion coefficient were not obtained, this admixture is not confirmed. The experimental K/L ratios of the 281.1 and 381.5 kev transitions are not reliable because of the poor statistics. The multipolarities of these transitions are probably E1 from their K conversion coefficients. This is also the case for the 422.5 kev transition.

3.3. Decay scheme

A proposed decay scheme is shown in Fig. 5, which includes all the transitions observed in this work. The main features of the scheme are similar to those in the Nuclear Data Sheets.[8] But a new level of 308 kev is proposed and the possible spins and parities are assigned to six levels. The discrepancies in the energy relations are also improved. The intensities of the transitions are given as the percentage per disintegration. For the transitions not observed in the scintillation study, their intensities are calculated from the relative electron intensities and their multipolarities.

From the facts that the 187.6 and 195.0 kev transitions are particularly strong and not coincident with each other, both transitions are considered to go directly to the ground state. The coincibence pair of the 140.3 and 54.5 kev transitions is a cascade transition in parallel with the 195.0 kev crossover transition. Since the 54.5 kev transition is stronger than the 140.3 kev transition, the 54.5 kev transition must be preceded by the 140.3 kev transition. The energy of the 479 kev transition agrees with the energy sum of the 422.5 and 54.5 kev transitions and with that of the 281.1 and 195.0 kev transitions. This indicates the existence of the 477 kev level. The existence of the 436 kev level is suggested by the energy sum relations including the new 240 and 250 kev transitions: $381.5+54.5=436.0$, $240+195.0=435$ and $250+187.6=437.6$. Three new transitions of energies 308, 114.5 and 169 kev are well fitted into the level scheme with a newly

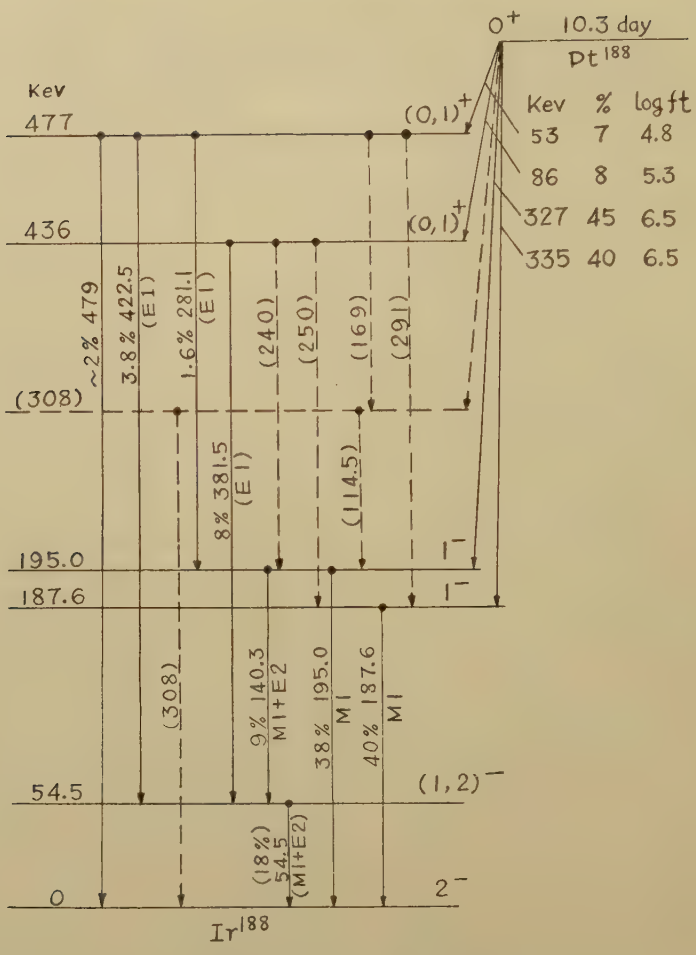

Fig. 5. Proposed decay scheme.

proposed level at 308 kev. The new 291 kev transition is considered to occur between the 477 and 187.6 kev levels.

The proposed decay scheme is consistent with the data on the relative intensities of the transitions except the 54.5 kev transition. The intensity of this transition calculated from the observed conversion line intensity is 18% per disintegration, while the sum of the intensities of all transitions leading to this level is 21% per disintegration. This discrepancy may be explained as follows: The L conversion line intensities of this transition are rather ambiguous as discussed in §2. Furthermore, neither the M, N, ·· lines nor the gamma-ray were observed and the total intensity of this transition is obtained from the L line intensity by assuming the M+N+··/L ratio and the M1+E2 mixing ratio. For these reasons, the calculated intensity of this transition is rather uncertain and the above discrepancy may be considered to be within experimental error. The intensities of the new transitions are neglected because of their low intensities.

The log ft values of electron capture transitions are calculated with the assumption that the Q value is 523 kev as in the Nuclear Data Sheets.[8]

Pt^{188} is even-even and its ground state is 0+. The ground state of Ir^{188} is considered to be 2− from the fact that it decays to both 0+ and 4+ levels of Os^{188} with the log ft values of 9.3. Both the 195.0 and 187.6 kev levels are either 1− or 3−, since the transitions from these levels to the ground state are both M1. The relatively low log ft value of 6.5 for the electron capture transitions to these levels excludes 3− assignment for these levels. Thus the spins and parities of these levels are determined to be 1−. Then, the electron capture transitions to these levels appear to be 1st forbidden, unhindered. From the M1+E2 character of both the 140.3 and 54.5 kev transitions, the 54.5

kev level is either 1− or 2−. The log ft values of 4.8 and 5.3 for the electron capture transitions to the 477 and 436 kev levels, respectively, indicate that both the transitions are allowed. Then, both the 477 and 436 kev levels are either 0+ or 1+. This is consistent with the E1 character of the 281.1, 422.5 and 381.5 kev transitions.

The energy levels of the neighbouring odd and odd-odd nuclei have not been established as yet. Coupling rules and transition selection rules in odd-odd nuclei are still uncertain. Therefore, it is too early to compare the results with the various nuclear models. But in the further discussion of the level structure it will be helpful to note the following facts: The 195.0 and 187.6 kev levels are very similar in the energy value, spin and parity, log ft value, and intensity of M1 transition to the ground state. Nevertheless, the transition to the 54.5 kev level from the 195.0 kev level is observed but that from the 187.6 kev level is not observed.

ACKNOWLEDGEMENTS

The author would like to express his sincere gratitude to Professor K. Kimura for his constant encouragement and support throughout this work. He also wishes to express his gratitude to Professor K. Ohira and Dr. F. Fukuzawa for their many valuable discussions; to Dr. H. Ikegami, Mr. T. Yamazaki and Dr. M. Sakai for their invaluable help in performance of this experiment; to Professor S. Shimizu and his co-workers for their help in measurement of the relative gamma-ray intensity. The author is particularly indebted to Professor T. Fujinaga, Mr. M. Koyama and Dr. T. Nagai who carried out all of the chemical separations. Finally he would like to thank the cyclotron crew of the Institute for Nuclear Study of the University of Tokyo for the cyclotron bombardment.

This work was partly supported by a grant-in-aid for scientific research of the Ministry of Education.

(Laboratory of Physics,
Received Aug. 31, 1961)

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EXCITED LEVELS OF Pd^{105}

Kyōzō ŌHIRA

As a part of the systematic survey of the medium weight odd-A nuclei, conversion electrons and gamma-rays of Pd^{105} following the decay of 40 day Ag^{105} have been studied with a double focusing beta-ray spectrometer, a thin lens beta-ray spectrometer and scintillation spectrometers. Gamma-gamma angular correlations have also been measured. The strong 654 kev transition previously considered to be a single transition was decomposed into the 645 kev (E1) and 649 kev (M1, E2) transitions, and further a new weak gamma-ray of 620 kev (M1, E2) was observed. This result removes the ambiguity about the transition rate in the level scheme. On the basis of the multipolarities of transitions and *ft* values for the electron captures, the following assignments are given: 649 kev (3/2, 5/2+), 620 kev (5/2+) and 501 kev (5/2+). The other results obtained are consistent with the level scheme given in the Nuclear Data Sheets. A value of 4×10^{-5} for the ratio

$$\frac{\{B(M1,\ 5/2\longrightarrow 7/2)/B(E2,\ 5/2\longrightarrow 5/2)\}_{exp}}{\{B(M1,\ 5/2\longrightarrow 7/2)/B(E2,\ 5/2\longrightarrow 5/2)\}_{SN}}$$

is obtained for the cascade M1 and crossover E2 radiations from the 344 kev level. This indicates that the E2 radiation from the 344 kev level is considerably enhanced; B(E2) is about 25 times as large as single particle estimation.

1. INTRODUCTION

For even-even nuclei in the medium weight region, there are many systematic studies on the level energy, spin and transition probability, and various nuclear models[1)~6)] are proposed to explain these data. The investigation of the structures of the odd mass nuclei in this mass region is very interesting because it may give some measure for the validity of the above models. There is, however, no systematic study on these odd mass nuclei because of the large variation of the ground state configurations and the lack of information concerning the characters of many excited levels.

In this paper the excited levels of Pd^{105}, whose level scheme is not fully established until now, are described. This investigation is a part of the systematic study of the odd mass nuclei in the medium weight region.

The levels of Pd^{105} have been studied by many authors.[7)~16)] Hayward and Hoppes[9)] have measured the relative intensity of the 64 kev, 281 kev, 345 kev, 443 kev and 654 kev gamma-rays and found the coincidence pairs of 64 kev $\gamma-281$ kev γ, 319 kev $\gamma-331$ kev γ and 443 kev $\gamma-654$ kev γ. Further they have assigned the 64 kev and 281 kev transitions to be M1 and 345 kev transition to be E2. Raether[10)] has confirmed the 1090 kev level by observing the 1090 kev gamma-ray and established the existence of 281 kev level by studying the coincidence pair of 281 kev $\gamma-393$ kev γ. He has assigned the spin and parity of the 281 kev, 345 kev levels to be 7/2+ and 5/2+ respectively from the measurement of the angular correlation, and further estimated the upper limits of the life times of 281 kev and 443 kev levels to be $1\sim2\times10^{-9}$ sec and 4×10^{-9} sec, respectively. Boedege[11)] has obtained the following results from the measurement of the external conversion electrons: $\alpha_K(642\text{ kev}) = (1.2\pm0.2)\times10^{-3}$, $\alpha_K(436\text{ kev}) = (7.5\pm1)\times10^{-3}$. On the basis of the *ft* value, Nozawa[12)] has pointed out that the electron capture to the 1085 kev level is an allowed transition. Boyd[13)] has suggested on the basis of the *ft* values of the bata decay of Rh^{105} that the spin and parity of 319 kev level is 7/2+. The data on the Coulomb excitation[14)~16)] have indicated the E2 enhancement for 270 kev and 430 kev transitions.

In spite of these experimental studies, there remain some uncertainties over the internal conversion coefficients, the relative intensities of transitions, gamma-gamma angular correlations and the spins and parities of levels. Thus the present measurements of the conversion electsons, gamma-rays and gamma-gamma angular correlation were undertaken in order to resolve some of the previ-

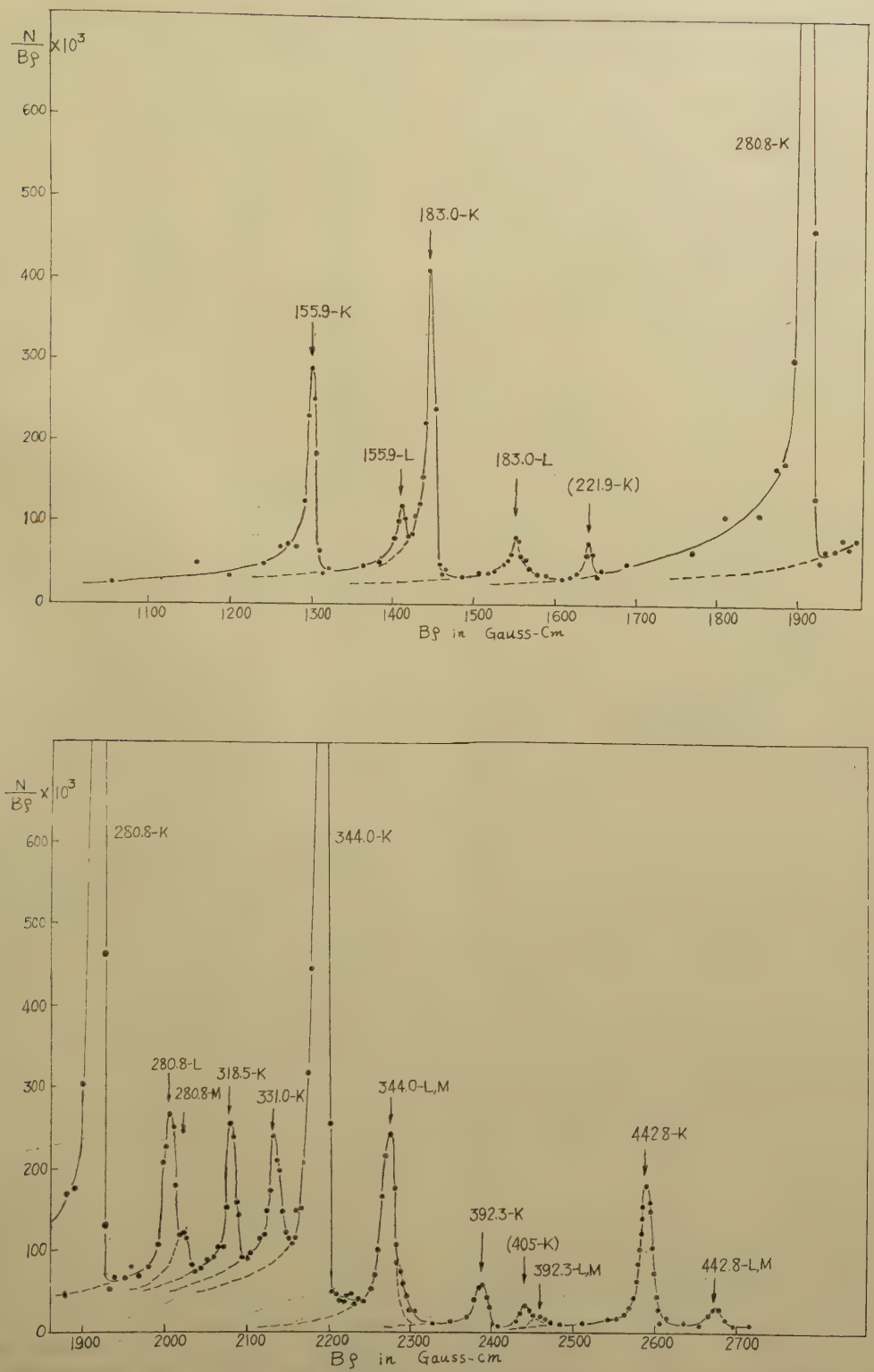

Fig. 1. Conversion electron spectrum

ous uncertainties and to study the level structure more completely.

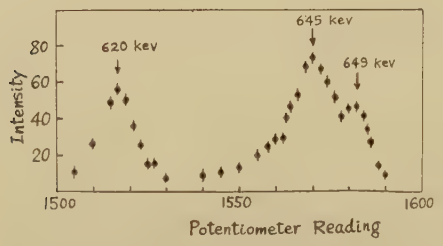

Fig. 2. 620 kev, 645 kev and 649 kev conversion electrons.

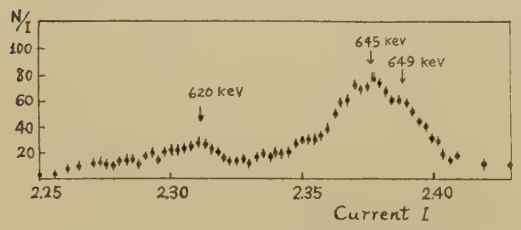

Fig. 3 620 kev, 645 kev and 649 kev conversion electrons.

2. EXPERIMENTAL PROCEDURES AND RESULTS

2.1. Source Preparation

The Ag^{105} used in the present work was produced in the cyclotron of the Institute for Nuclear Study of the University of Tokyo by an $(\alpha, 2n)$ reaction on Rh^{103} powder, pressed to the thickness of 0.2 mm. The bombarding energy of α-particles was chosen to be 33 Mev so that the ratio of Ag^{105} to Ag^{106}, produced by $Rh^{103}(\alpha, n)Ag^{106}$ reaction, was about 10. Total intensity of bombarding α-particles was about 15 to $20\mu A \times 35$ hours. Electron sources, 3 mm by 20 mm, were prepared by electroplating the Ag^{105} from the $AgNO_3$ solution, prepared by chemical separation, onto 0.01 mm Al foils.* The $AgNO_3$ solution, dropped into a cylindrical container with inner diameter of 2 mm and depth of 2.5 mm, was used as the source for the gamma-ray measurement and the gamma-gamma angular correlation measurement.

2.2. Conversion Electron Spectrum

Internal conversion electrons were examined with INS III sector-type double focusing beta-ray spectrometer[17] at 0.7% resolution. The detector was a 1 mg/cm² mica window G-M counter. Only the 64 kev-K, L and M lines were corrected for window absorption using the curve published by Saxon.[18] A thin lens beta-ray spectrometer was also used at about 1% resolution with relatively strong source for measurements of relatively higher energy lines.

Table I. Conversion lines in Pd^{105}

Electron energy (kev)	Shell	Relative intensity	Transition evergy (kev)
39.6	K		64.0
60.5	L		
63.5	M		
131.5	K	3.9	155.9
152.1	L	0.5	
158.7	K	6.1	183.0
179.9	L	0.77	
256.4	K	27.	280.8
277.1	L	3.5	
280.6	M	1.	
294.1	K	2.9	318.5
306.7	K	2.5	331.0
328.4	L		
319.7	K	28.	344.0
340.2	L	4.05	
367.9	K	1.2	392.3
418.6	K	3.5	442.8
439.2	L	0.48	
596.	K	~0.05	620.
620.	K	0.53	645.
624.	K	0.26	649.
			790.
1061	K	~0.07	1085.

Transition energies were determined relative to the 64 kev-and 280.8 kev-K lines from the conversion spectrum obtained with the double focusing beta-ray spectrometer and listed in Table I. Typical electron spectra are shown in Figs. 1 and 2. The energy of the 790 kev transition was determined by analyzing scintillation gamma-ray spectrum (Fig. 5). The energy of the 1085 kev transition was obtained from the conversion electron spectrum observed with thin lens beta-ray spectrometer. It was found that the 654 kev transition previously considered to be a single transition splitted into two transitions of energies 645 and 649 kev, as clearly seen in Fig. 2. Further, the conversion spectrum measured with the lens spectrometer two months after bombardment showed clearly the existence of the 620 kev-K line, which

* The chemical procedure will be described in detail elsewhere by M. Koyama et al..

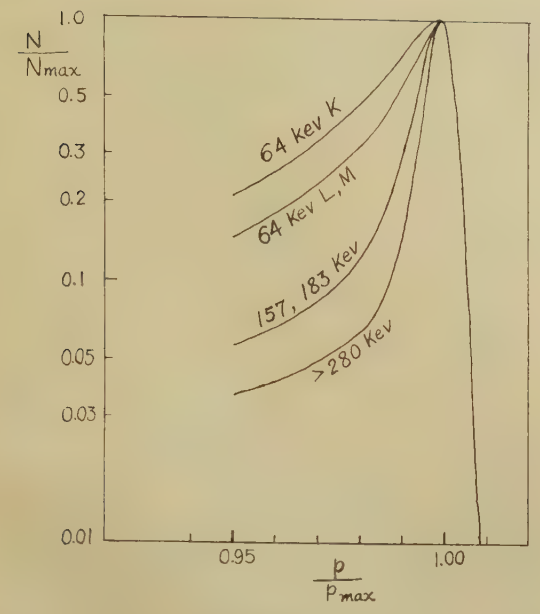

Fig. 4 Reduced line profiles.

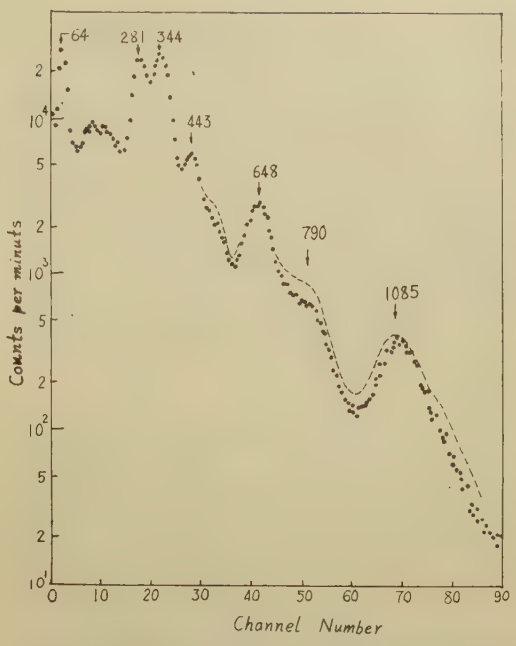

Fig. 5 Gamma-ray spectrum of $Pd^{105+106}$

was confirmed to be of Pd^{105} from its decay (Fig. 3).

In estimating the relative electron intensities exactly from very complex spectrum, it is a very diffiicult problem how to subtract the contributions from the higher energy electron lines. The following procedure was used in the present work: The reduced line profile* for all lines above about 250 kev was assumed initially to be that of the 442.8 kev-K line as shown in Fig. 4. Using this line profile for all lower energy lines of 392.3 kev-K, L, 344.0 kev-K, L, 331.0 kev-K, 318.5 kev-K and 280.8 kev-L, and subtracting the contributions from these lines successively from the complex spectrum, the reduced line profile of the 280.8 kev-K line was obtained. This line profile was then compared with initially assumed one. This procedure was repeated until an agreement of two line prifiles was attained. It was found that the spectrum can be analysed satisfactorily by use of the identical line profile for all lines in the energy range 250–450 kev. This indicates that the effect of the source thickness is negligible above 250 kev. For the 183.0 kev-K, L lines and the 155.9 kev lines, the effect of the source thickness could not be neglected and another reduced line profile was needed to apply the subtraction method.

The relative intensities of electrons obtained by

Table II Conversion ratio

Transitions (kev)	K/L (Theoretical)				K/L (Experimental)
	E 1	M 1	E 2	M 2	
155.9	8.39	8.13	5.60	6.42	7.9
183.0	8.44	8.17	6.05	6.70	7.9
280.8	8.54	8.24	6.84	7.23	7.9±0.4
344.0	8.57	8.26	7.05	7.43	7.0±0.3
392.3	8.58	(8.28)	7.14	7.54	8.2 †
442.8	8.57	(8.30)	7.20	7.63	8.6±0.4

† K/L+M

* $\left(\frac{\text{counts /momentum}}{\text{peak counts/ momentum}}\right)$ *vs* $\left(\frac{\text{momentum}}{\text{peak momentum}}\right)$ -curve is here called as "reduced line profile".

this self-consistent background subtraction method are considered to be in good precision (Table I).

In Table II the experimental K/L and K/L+M ratios are compared with theoretical ones deduced from the Sliv's tabulations.[19] The value of K/L+M for the 392.3 kev and K/L value for the 155.9 kev transition have not been reported previously. The values of K/L for the 442.8 kev, 344 kev and 183 kev transitions obtained in the present work are considerably different from the previously reported ones. The relative electron intensity for the 64 kev line is not discussed because of the ambiguities in absorption correction in the present work.

2.3. Gamma-ray Spectrum

Gamma-ray spectrum was obtained with INS scintillation spectrometers. The detectors were 1½ in.×2 in. NaI crystals which were mounted on RCA 6342 photo-multiplier tubes. Source to detector distance was 7 cm. The resolution of each detector was 11.8% for the 662 kev gamma-ray peak of Cs^{137}. The output pulses were recorded by the 20 channel pulse height analyzer.

The singles spectrum includes the gamma-rays of Pd^{106} contamination ($Rh^{103}(\alpha, n)Ag^{106} \longrightarrow Pd^{106}$), that is shown by dashed curve in Fig. 5. We subtracted the contributions from the 14 gamma-rays of Pd^{106} by referring to the relative intensities of Pd^{106} gamma-rays reported by Robinson et al.[20] and by normalizing their intensities to that of the 1544 kev peak observed in the present measurement.

The Pd^{105} gamma-ray spectum thus obtained was decomposed into 8 gamma-rays by the usual successive subtraction method. The response curves of gamma-rays were deduced from the spectra of Na^{22}, Zn^{65}, Y^{88}, Cs^{137}, Cr^{51} and Hg^{203}. The gamma-rays of these isotopes were also used as the standards for energy calibration. And further the peak-to-total ratios were estimated from these spectra.

We determined the relative intensities of Pd^{105} gamma-rays by measuring the areas under full-energy peaks and by correcting for the total intrinsic efficiency[21] and peak-to-total ratio of the crystal. The intensities, which are normalized to a value of 100 for the intensity of the 344 kev γ-ray, are listed in Table III.

Table III Relative intensity of gamma-rays

γ-rays (kev)	Relative intensity
64	20 ±2
156, 183	11
281	61 ±5
344	100 ±8
443	25 ±3
620, 645, 649	35 ±4
790	2.2±1.4
1085	8.1±1.2

The internal conversion coefficients are determined from these relative intensities and the relative electron intensities by assuming the theoretical E2 value for α_K of the 344 kev transition (Table IV). The multipolarity of this transition is known to be E2 from the K/L conversion ratio observed in the present work. This assignment is in agreement with the result of the previous work.

2.4. Gamma-Gamma Angular Correlations

For the gamma-gamma angular correlation measurements, the source consisted of $AgNO_3$ solution which was contained in the plastic holder with a cylindrical hole 2 mm i.d. and 2.5 mm depth. The source was 7 cm from each detector. A resolving time 2τ of the fast-slow coincidence circuit, used for this measurement, was 8.5×10^{-8} sec. Data were taken every 18° between 90° and 180°. A least-squares fit of the data was made to the func-

Table IV Conversion coefficient

Transitions (kev)	$10^3\alpha_K$ (Theoretical)				$10^3\alpha_K$ (Experimental)
	E 1	M 1	E 2	M 2	
280.8	7.30	20.5	31.3	94.0	24.6±4.0
344.0	4.23	12.2	16.3	49.4	(16.3)
442.8	2.24	6.45	7.6	22.3	7.1±1.3
645. †	0.95	2.63	2.54	7.9	1.2±0.2
1085.	0.324	0.835	0.732	1.92	0.44±0.1

† 620, 645, 649 kev compound peak

Table V Angular correlation of the 645-443 kev cascade

Sequence	A_2	δ	Mixture
Experimental	-0.124 ± 0.023		
$\frac{1}{2}(D)\frac{3}{2}(Q+D)\frac{5}{2}$	-0.124 ± 0.023	-0.36 -1.60	11.5%Q+88.5%D 71.8%Q+28.2%D
$\frac{3}{2}(D)\frac{3}{2}(Q+D)\frac{5}{2}$	〃	0.18 -25.4	3.0%Q+97.0%D 99.8%Q+ 0.2%D
$\frac{3}{2}(D)\frac{5}{2}(Q+D)\frac{5}{2}$	〃	2.03 -0.09	80.5%Q+19.5%D 0.8%Q+99.2%D
$\frac{5}{2}(D)\frac{5}{2}(Q+D)\frac{5}{2}$	〃	-0.76 -9.5	36.8%Q+63.2%D 98.9%Q+ 1.1%D
$\frac{5}{2}(D)\frac{7}{2}(Q+D)\frac{5}{2}$	〃	5.9 0.40	97.2%Q+ 2.8%D 13.7%Q+86.3%D

tion $W(\theta)=1+A_2P_2(\cos\theta)+A_4P_4(\cos\theta)$. The results were then corrected for the finite angular resolution of the detectors.[22] Since the spin values of the 1085 kev and 443 kev levels were uncertain, the angular correlation of the 645-443 kev cascade was studied. To obtain the angular correlation of this cascade, the effects of 618-513 kev coscade[20] (Pd^{106}), 1050-513 kev casdade[23] (Pd^{106}), 1537-725 kev cascade[20] (Pd^{106}) and 1544-513 kev cascade[20] (Pd^{106}) were taken into account carefully. The gamma-gamma angular correlations of these cascades were measured previously. Further, the effects of 12 coincidence pairs, which were all attributed to Pd^{106}, were estimated using their coincidence data[20] and decomposed spectral distributions. The other coincidence pairs have negligible effects. The experimental angular correlation coefficient for the 645-443 kev cascade is given in Table V. Also given in the same table are the theoretical correlation coefficients which are obtained for different spin values of the 1085 kev and 443 kev levels. For upper level spins 1/2, 3/2 and 5/2, and lower level spins 3/2, 5/2 and 7/2, the values of δ and its error $\triangle\delta$ are chosen to give an agreement between the theoretical and experimental cofficients and errors. In the above calculations, it is assumed that the 645 kev transition is pure E1 and the 443 kev transition is M1+E2 from the observed values of α_K and K/L (discussed in the following sectson).

Table VI Multipolarity

Transitions (kev)	Multipole order	Transitions (kev)	Multipole order
64	(M1)	392.3	(M1, E2)
155.9	(M1)	442.8	M1+E2
183.0	(M1)	620.	(M1, E2)
280.8	(M1)	645.	E1
318.5	(M1, E2)	649.	(M1, E2)
331.0		790.	
344.0	E2	1085.	E1

3. DISCUSSION

3.1. Multipolarities and Relative Transition Rates

The multipolarity assignments are deduced by comparing the experimental conversion coefficients and conversion ratios with the theoretical Z=46 values deduced from Sliv's tabluations,[19] and by considering the changes of spin and parity between the initial and final states (Table VI). The experimental values of α_K and K/L ratio of the 443 kev transition suggest that its multipolarity is M1+($\lesssim$10%)E2 or M1. In consideration of the Coulomb excitation data,[14)~16] the case of M1+($\lesssim$10%)E2 seems to be favourable. The observed value of α_K, $(1.2\pm0.2)\times10^{-3}$, for the compound transition consisting of the 620, 645 and 649 kev transitions is in complete agreement with the result obtained by Boedege[11] in the measurements of the external conversion electrons. This value shows that the strongest transition of the above three, the 645 kev transition, must be E1 transition. Among several possible combinations of the multipolarities for the 620 kev and 649 kev transitions, only the combination of (M1, E2) for 620 kev transition and (M1, E2) for 649 kev transition is compatible with the log ft values of electron captures to the 620 kev and 649 kev levels. The conversion coefficient of the 1085 kev transition indicates it consists primarily of E1 transition. From K/L values both the 155.9 kev and the 183 kev transitions are considered to be M1 predominant. The 392 kev transition is suggested to be (M1, E2) from the observed value of K/L+M and spin parity change between the initial and final states.

From these assumed multipolarities, conversion

Table VII Comparative half-lives of the Ag^{105} electron capture

Terminating level (kev)	Log *ft*	Type
1085	5.5	allowed
790	8.0	1st forbidden
673	7.7	unique 1st forbidden
649	7.5	unique or non-unique 1st forbidden
620	8.6	unique 1st forbidden
501	7.7	unique 1st forbidden
344	6.9	(1st forbidden)

coefficients and the relative intensisites of gamma-rays and conversion electrons, the transition rates are deduced and shown in percent per decay in Fig. 6. The intensity of gamma-ray terminating at 443 kev level turns out to agree within the errors with the intensity of gamma-ray originating at this level, by splitting of the compound 654 kev transition into the 645 kev and 649 kev transitions. Thus, the decay scheme with consistent transition rates may be obtained (Fig. 6).

3.2. *ft*-values and Level Assignments

The log *ft* values are estimated from the above transition rates and the Q-value, $1.2^{+0.5}_{-0.1}$ Mev, which was given by Raether,[10] and listed in Table VII. If the types of electron capture transition listed in Table VII are assumed, these log *ft*-values are consistent with the spins and parities of levels in Pd^{105} which are predicted from the multipolarities and the angular correlation. Only the comparative half-life of the transition to the 344 kev level is too small. We have no explanation for this inconsistency.

Since the ground state transition from the 1085 kev level is E1 transition, this level is expected to have odd parity and spin of 3/2, 5/2 or 7/2. Further, a spin assignment of 5/2 or 7/2 for this level is eliminated by the log *ft* value, 5.5, of the transition which populates this level. Thus the 1085 kev level is assigned to be 3/2−.

Among the possible spin sequences for the 645–443 kev cascade listed in Table V, only two sequences 3/2(D)3/2(3%Q+97%D)5/2 and 3/2(D)5/2(0.8%Q+99.2%D)5/2 are compatible with the spin value 3/2 of the 1085 kev level and the multipolarity of the 443 kev transition, M1+(≤10%)E2 or M1. Even if there is no criterion by which the most probable spin sequence is decided, the sequence 3/2(D)3/2(3%Q+97%D)5/2 seems to be more probable in consideration of the fact that the 433 kev gamma-ray is observed in the Coulomb excitation experiments.[14)~16)] Thus the 443 kev level is assigned to be 3/2+ (or 5/2+).

The 649 kev transition which was separated from the 654 kev compound peak in the present work, is assumed to be the crossover transition in parallel with the 331-319 kev cascade. The value of the comparative half-life of the transition to the 649 kev level, 7.5, seems to be characteristic of unique or non-unique 1st forbidden transition. Thus the 649 kev level is assumed to have even parity and spin 3/2 or 5/2. These spin values are compatible with the probable multipolarity, (M1, E2), for the

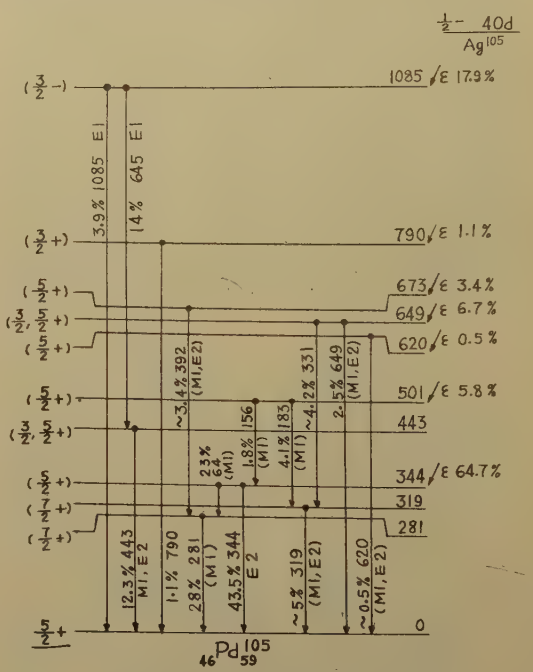

Fig. 6 Proposed level scheme.

649 kev ground state tansition.

It is suggested that the 620 kev level has even parity and spin 5/2, from the log *ft* value, 8.5, of the transition to the tentative 620 kev level and the assumed multipolarity, (M1, E2), for the 620 kev ground state transition.

The log *ft* value, 7.7, of the transition to the 501 kev level is assumed to be characteristic of the unique 1st forbidden transition. This value and the assigned multipolarity, M1, of the 183 kev transition from this level to the 319 kev level (7/2+), and of the 156 kev transion from this level to the 344 kev level (5/2+), are all consistent with the tentative assignment, 5/2+, of the 501 kev level.

3.3. Reduced Transition Probability

The branching ratio of the cascade to crossover gamma-rays from the 344 kev level (5/2+), which is the uppermost level of the well known 64-281 kev cascade, is 0.229 ± 0.035. This branching ratio gives a value of 4.12×10^{-5} for the ratio

$$\frac{\{B(M1, 5/2 \longrightarrow 7/2)/B(E2, 5/2 \longrightarrow 5/2)\}_{exp}}{\{B(M1, 5/2 \longrightarrow 7/2)/B(E2, 5/2 \longrightarrow 5/2)\}_{SN}} \equiv \frac{B(M1)_{exp}}{B(M1)_{SN}} \cdot \frac{B(E2)_{SN}}{B(E2)_{exp}}$$

where $B(M1, 5/2 \longrightarrow 7/2)$ and $B(E2, 5/2 \longrightarrow 5/2)$ are the reduced M1 transition probability between the 344 kev 5/2+ level and the 281 kev 7/2+ level and the reduced E2 transition probability between the 344 kev 5/2+ level and the ground state (5/2+), respectively. $\{B(M1)/B(E2)\}_{SN}$ is the single neutron estimate[24] of this ratio.

The average value for the various nuclei of the ratio, $\frac{B(M1)_{exp}}{B(M1)_{SN}}$, is 1/10~1/1000.[25] The estimation of this ratio for the M1 transition between the 281 kev 7/2+ level and ground state in Pd^{105} gives a value of about 1/1000, using the upper limit of the life time of the 281 kev level, $1 \sim 2 \times 10^{-9}$ sec, which has been given by Raether.[10]

If the ratio $\frac{B(M1)_{exp}}{B(M1)_{SN}}$ for the M1 transition between the 344 kev and the 281 kev levels is assumed to be of this order, the following result is obtained

$$\frac{B(E2, 5/2 \longrightarrow 5/2)_{SN}}{B(E2, 5/2 \longrightarrow 5/2)_{exp}} \lesssim \frac{1}{25}$$

This means that the enhancement factor F of the E2 transition is equal to about (or larger than) 25. Since the average value of F is 20~50 in the vibrational region,[16] while that is 100~150 in the rotational region,[26] the 344 kev level may be considered to have probably vibrational character.

ACKNOWLEDGMENTS

The author would like to express his sincere gratitude to Professor K. Kimura for his constant encouragement and support throughout this work. He also wishes to express his gratitude to Porfessor H. Matsui and Dr. F. Fukuzawa for their many valuable discussions; to Dr. H. Ikegami, Dr. M. Sakai and Mr. T. Yamazaki for their invaluable help in performance of this experiment; to Professor S. Shimizu for his constant encouragement. The author is particularly indebted to Professor T. Fujinaga, Mr. M. Koyama and Mr. T. Mitsuji who carried out all of the chemical separations. Finally he would like to thank the cyclotron crew of the Institute for Nuclear Study of the University of Tokyo for the cyclotron bombardment.

This work was partly supported by a grant-in-aid for scientific research of the Ministry of Education.

(Laboratory of Physics,

Received Aug. 31, 1961)

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昭和36年12月20日 印刷
昭和36年12月25日 発行

兵庫農科大学研究報告 第5巻 第1号
自然科学編

編集兼発行 兵庫農科大学
兵庫県多紀郡篠山町

印刷所 藤本印刷所
兵庫県多紀郡篠山町郡家299
電話（篠山）320番